QUESTIONS AND ANSWERS IN OPTOMETRY

TAVS

FOREWORD

From the earliest times the catechism has been the most impressive and effective method of imparting and receiving knowledge. It was the method used by the greatest of all philosophic teachers, Socrates, in inculcating his doctrines into his pupils, whence it has come to be known as the Socratic method; and in all ages it has been employed by teachers, both of children and of adults, with powerful effect. It establishes a vital contact between teacher and student which no other method possesses, and permits of an easy and natural graduation from the theoretical to the practical phases of the subject.

With this truth in mind, the author has taken the facts and principles of ocular refraction and set them forth in question-and-answer form, whereby the student may acquire his knowledge in living, mouth-to-ear fashion, so that every item may be impressed upon his mind with the same unforgettable emphasis which would attend a course of personal instruction from the lips of a living teacher. In this way the subject acquires a freshness and force that it could attain in no other way.

The author has endeavored to compass every aspect of the subject with the greatest possible breadth and thoroughness. The publishers have devoted their energies and experience to furthering the didactic purposes of the book by the best possible arrangement and physical qualities of the volume. How successful both have been in their efforts is now left to the reader to judge.

CONTENTS

ABBREVIATIONS AND SIGNS USED IN REFRACTION

A. or acc.—Accommodation.

A.M.—Ametropia.

An.—Anisometropia.

As.—Astigmatism.

Asth.—Asthenopia.

As. H.—Hyperopic astigmatism.

As. M.—Myopic astigmatism.

Ax.—Axis.

B.—Base (of prism).

C.c.—Concave or minus.

CM.—Centimeter.

Cx.—Convex or plus.

Cyl.—Cylinder.

D.—Dioptry.

D.C.c.—Double concave.

D.Cx.—Double convex.

D.T.—Distance test.

E. or Em.—Emmetropia.

e.g.—For example.

F.V.—Field of vision.

H. or Hy.—Hypermetropia.

In.—Inches.

L. or Le.—Left eye.

M. or My.—Myopia.

MM.—Millimeter.

M.—Meter.

M.A.—Meter angle.

N.—Nasal.

O.D.—(Oculus Dexter), right eye.

O.S.—(Oculus Sinister), left eye.

O.U.—(Oculi Unati), both eyes.

Oph.—Ophthalmology.

Prb.—Presbyopia.

P.Cc.—Periscopic concave.

P.Cx.—Periscopic convex.

P. D.—Inter-pupillary distance.

Pl.—Plano.

P.P.—Punctum proximum, near point.

P.R.—Punctum remotum, far point.

Pr. D.—Prism diopter.

R. or Re.—Right eye.

Rx.—Prescription.

Sb.—Strabismus.

S. or sph.—Spherical.

t.—Temporal.

T.—Tension.

V.—Vision.

W.P.—Working point.

+—Plus convex.

— —Minus concave.

=—Equal to.

⌒—Combined with.

°—Degree.

°°—Infinity, 20 feet or more, distance.

△Prism diopter.

△Centrad.

‴—Line.

″—Inch, second.

′—Foot, minute.

×—Times, multiplied by.

÷—Divided by.

>—Greater than.

<—Less than.

?—Why.

Chapter I

PHYSICS OF LIGHT

Q. What is light?

Ans. Light is a form of radiant energy which, acting upon the sensitive elements of the retina, gives rise to visual sensations.

Q. How is this form of radiant energy propagated?

Ans. This form of radiant energy is propagated in all directions from a luminous body. There exists a certain medium called ether which penetrates all space. That radiant energy causes it to vibrate and imparts to it a wave-like motion.

Q. What is the wave theory of light?

Ans. The theory that all space is filled with luminiferous ether and that luminous bodies set this ether in motion in the form of spherical light waves.

Q. How does light manifest itself?

Ans. It is made manifest in vision.

Q. What is the velocity of light? When was it discovered?

Ans. Light has a velocity of about 188,000 miles per second in vacuum. That light has velocity was discovered by Roemer in 1676.

Q. Upon what does the velocity of light depend?

Ans. The velocity of light depends upon the density of the medium in which it is traveling.

Q. How is light created?

Ans. Light is created by the rapid vibration of the particles of a luminous body.

Q. What is meant by a ray of light?

Ans. Physically there is no such thing. It is a geometric straight line perpendicular to the surface of a light wave, denoting the nature of its curvature and direction of its travel, and used for demonstrating geometric functions of the wave.

Q. What is meant by the term "incident ray"?

Ans. The incident ray is a ray of light proceeding from a source of light directly or indirectly and falling on the surface of some object.

Q. What is meant by the terms refracted ray and emergent ray?

Ans. A refracted ray is a ray of light after it has been deviated or bent. The emergent ray is the ray of light after it comes out from the second medium.

Q. What is the ray called after it rebounds from a polished surface?

Ans. The reflected ray.

Q. What is meant by reflection?

Ans. It is the rebounding or the throwing back of rays of light after striking a substance. The reflection is regular from a polished surface and irregular from an unpolished surface.

Q. How many luminous sources are contained in a candle flame?

Ans. The candle flame is composed of millions of incandescent particles of carbon.

Q. What are the laws of reflection?

Ans. The angle of reflection and the angle of incidence are always equal. The reflected and incident rays are both in a plane perpendicular to the reflecting surface.

Q. What is the angle of reflection?

Ans. The angle of reflection is the angle formed by the reflected ray with the perpendicular of the surface at the point where the incident ray strikes the surface.

Q. What is the angle of incidence?

Ans. The angle of incidence is the angle formed by the incident ray with the perpendicular of the surface at the point where the incident ray strikes the surface.

Q. What is regular reflection?

Ans. Regular reflection is from a smooth surface which returns the light in exactly the same condition as it is received.

Q. What is irregular reflection?

Ans. Irregular reflection is from an irregular surface, which absorbs a part of the light and reflects other parts, thus producing different wave lengths.

Q. In what direction do waves travel from a luminous point?

Ans. Waves from a luminous point are divergent and travel in straight lines indicated by rays as long as they do not meet some other optical medium obliquely.

Q. What is a luminous body?

Ans. A body which is in itself a source of light, as the sun, candle flame, etc.

Q. How are non-luminous bodies rendered visible?

Ans. A non-luminous body is rendered visible by the waves of light it reflects to our eyes.

Q. What is a translucent body?

Ans. A condition between transparent and opaque. Permitting partial transmission of light.

Q. What is the difference between transparent and opaque substances?

Ans. A transparent substance is one we can see through clearly. An opaque body is one that shuts off all light that falls upon it.

Q. How many kinds of reflecting surfaces have we?

Ans. Plane and curved. Polished and unpolished, etc.

Q. What is the unit of light?

Ans. The unit of light is one candle power.

Q. What is the standard candle power?

Ans. A sperm twenty-two and one-fourth m m. in diameter with a wick of sufficient size to consume 120 grains of sperm oil per hour.

Q. What is meant by intensity of light?

Ans. By intensity is meant the degree of radiant energy expressed in candle power.

Q. Upon what does the intensity of light depend?

Ans. Upon the quantity of light contained in a given area. In the original source of light this depends upon what is known as the "incandescent" power of its substance. As its light diverges in all directions, it becomes spread over a larger and larger area; hence the intensity of light from any given source depends upon the distance from that source. Intensity decreases directly as the square of this distance.

Q. 60 c.p. on screen 10″ from a light the intensity is 60 c.p. What will the C.P. be on screen when placed 40 inches away?

Ans. Square each distance $40 \times 40 = 1600 \quad 10 \times 10 = 100$
Inverse proportion Then $60 : X :: 1600 : 100$

$$\frac{6000}{1600} = X = 3.75 \text{ C.P. Ans.}$$

Q. 20 C.P. on screen 80″. What will the C.P. be on screen if it is moved up to 15 inches?

Ans.

$80 \times 80 = 6400$
$15 \times 15 = 225$
Then $20 : X :: 225 : 6400$
$X = 568.88$ C.P.

Q. What is the intensity of light at four feet from its source as compared to 20 feet?

Ans. The intensity at four feet would be 25 times greater than at 20 feet.

Q. How much light intensity is secured on the test type through shortening its distance from the light source one half?

Ans. The intensity of the light would be four times as bright.

Q. In what ratio does the intensity of light diminish as it travels away from its source?

Ans. It decreases in intensity in proportion to the square of the distance traveled.

Q. What are the principal phenomena of light?

Ans. Absorption, dispersion, reflection and refraction.

Q. Give formula for calculating the intensity of light when the distance is increased.

Ans. To calculate the loss in intensity of light, divide the greater distance by the lesser then square the quotient and divide into C.P. quotient.

Q. If the index of certain glass is 1.50 how much would the speed of light be retarded while traveling in the glass? How much will the speed increase after it emerges from the glass?

Ans. While the wave travels in the glass its speed would be retarded ⅓. While in clear air light travels about 188,000 miles per second. If retarded ⅓ it would travel at the rate of 125,333⅓ miles per second while in the glass. When it passes back into air it picks up ½. As it lost 62,666⅔ miles per second while in glass, and 62,666⅔ equals ½ of 125,333⅓, taking the index of air as 1.00 and the glass having an index of 1.50 the glass is ⅓ denser, therefore, the speed would be retarded ⅓.

Q. If light travels through a glass at the rate of 116,250 miles per second, what is its index of refraction?

Ans. Since the index of air is 1.00 and light travels through it at the rate of 188,000 miles per second, then

$$\frac{188{,}000}{116{,}250} = 1.6175 \text{ index.}$$

Q. What is the refractive index of glass through which light travels at the rate of 94,000 miles per second? 123,440 miles per second?

Ans. To find the index of the substance we divide 188,000, the velocity of light in air, by the velocity it travels in the denser medium. Thus:

188,000 ÷ 94,000 = 2. index
188,000 ÷ 123,440 = 1.523 index.

Q. How would you find the velocity of light while traveling in a denser medium such as glass, with an index of refraction of 1.623?

Ans. The velocity of light in a dense medium is found by

dividing 188,000, the velocity of light in air, by the index of the medium in which it travels. Thus:

$$\frac{188{,}000}{1{,}623} = 115{,}834 \text{ miles.}$$

Q. Name seven definite colors which may be produced by separating the different waves of definite lengths which are found in white light.

Ans. Red, orange, yellow, green, blue, indigo and violet.

Q. Give two methods of producing a spectrum.

Ans. By reflection and refraction of drops of water and by refraction with a strong prism.

Q.—Which of the primary colors is refracted the most?

Ans. Violet is refracted the most.

Q. Which travels the faster—red or violet rays?

Ans. All ether waves travel at the same velocity. Violet waves are shorter and vibrate more rapidly.

Q. Which rays of the spectrum are refracted the least?

Ans. Red rays are refracted the least.

Q. What is ultra-violet light?

Ans. Those ether waves which are too short and rapid to stimulate the retina.

Q. What is infra red light?

Ans. Those ether waves which are too long and slow to stimulate the retina.

Q. Which colors make up white light and which of these have the greatest deviation in passing through a prism and which the least?

Ans. The colors of the spectrum are red, orange, yellow, green, blue, indigo and violet, of which red suffers the least deviation in passing through a prism and violet the most.

Q. What is the velocity of sound waves?

Ans. Sound waves traverse the air at the rate of about 1100 feet per second and about 5000 feet per second in water.

Q. Why is air taken as a standard?

Ans. Air is taken as the standard because it is the least dense of commonly encountered media. Its index is one (1).

Q. Give the wave lengths of the different colors found in white light.

Ans. The table gives the approximate wave lengths of the definite colors:—Red 0.000069 cm. Orange 0.000064 cm. Yellow 0.000059 cm. Green 0.000055 cm. Blue 0.000050 cm. Indigo 0.000045 cm. Violet 0.000040 cm.

Q. Which is more dense—warm or cold air?

Ans. Warm air is less dense than cold air and when light passes from one to the other in either direction its path is more or less bent.

Q. What is polarized light?

Ans. A change by which the transverse vibrations of light waves are limited to one single direction.

Q. Explain briefly a ray of polarized light.

Ans. When a ray of light is polarized particles of ether in that ray vibrate in straight lines, parallel to one certain direction in the front of the wave corresponding to the ray.

Q. Define angle of polarization.

Ans. The particular angle of incidence for which a plane transparent substance will reflect only vibrations parallel to its surface, is called the angle of polarization. The angle of polarization depends on the refractive index of the substance.

Q. Name some polarizing substances.

Ans. Glass, Polar Angle 54° 35′. Water 52° 45′, diamond 68°. Light reflecting from the surface of water, polished table, slate roof and oil paintings may be polarized. Polished metal surfaces do not give polarized light.

Q. In what way do heat waves differ from light waves?

Ans. First, they are waves communicated to material substances, instead of to ether. Second, they are longer and travel more slowly than light waves.

Q. If the angle of incidence is 45° and the index of the glass is 1.50, what would be the angle of refraction? Give rule.

Ans. The angle of incidence is to the angle of refraction as the index of the glass is to the index of air, thus:

45 : X :: 1.50 : 100 = 30 degrees.

Q. What is the difference between vertical and perpendicular?

Ans. Vertical is always directly up and down. Perpendicular may be horizontal, oblique or vertical because it means at right angles with another line.

Q. Light falls on a polished surface at an angle of 35 degrees. At what angle will it be reflected?

Ans. The law is that the angle of reflection is equal to the angle of incidence. Therefore, the angle of reflection in this case will be 35 degrees.

Q. What is meant by dispersion of light?

Ans. Dispersion of light is its division into different colors produced by the different wave lengths. It is due to the difference in the degree of deviations of the various rays by refraction.

Q. Why do different objects have different color?

Ans. Because they absorb all but certain wave lengths and those not absorbed are reflected. This produces a given, definite color or combination of colors.

Q. What is meant by absorption?

Ans. When light enters any transparent substance part of it is reflected, part of it is absorbed and part of it passes through. The light absorbed is neither reflected nor transmitted but changed into heat waves. Absorption takes place when part or all the primary colors of the spectrum are taken up. When all the colors are absorbed substances are said to be black.

Q. Do fluids, such as water, milk and alcohol absorb light?

Ans. Yes. Clear water absorbs about half the light that enters at a depth of about four feet and below the depth of about 300 feet all light is absorbed.

Q. What is meant by refraction?

Ans. Refraction is the bending of a ray of light when passing obliquely from one transparent medium into another of a different density.

Q. What are the laws of refraction?

Ans. A ray of light passing obliquely from a rare into a denser medium is refracted or bent toward the perpendicular. Light passing obliquely from a dense into a rarer medium is refracted or bent away from the perpendicular. When light passes from one medium into another of different density and strikes normal or perpendicular to the surface it is not refracted.

Q. Is the amount of refraction always the same for the same two media?

Ans. No. The deviation of light when refracted varies with the angle of incidence. The angle of refraction increases as the angle of incidence is increased and becomes smaller as the angle of incidence is reduced.

Q. When light passes from one medium into the other what three things may occur to it?

Ans. It may be reflected, refracted or absorbed.

Q. What are the four angles exhibited in connection with refraction?

Ans. Angle of incidence, reflection, deviation and refraction.

Q. Upon what does the amount of refraction depend?

Ans. The amount of refraction depends upon the obliquity of the ray at the point of incidence and the difference in density of the two media.

Q. What is the effect when light passes obliquely from a rarer to a denser medium?

Ans. It suffers reflection, refraction, dispersion and absorption and its speed is retarded. The denser the medium the slower the rate of speed of the ray.

Q. What three processes accompany refraction?

Ans. Reflection, Absorption and Dispersion.

Q. What is a focus? A negative focus?

Ans. A focus is a point where converging rays meet. A negative focus is a point from which diverging rays appear to come.

Q. What is meant by principal focus?

Ans. The point on the axial ray or principal axis where parallel rays of light come together after being refracted or reflected.

Q. What are secondary foci?

Ans. Secondary foci are all other foci.

Q. What is a secondary focus?

Ans. A secondary focus is the focal image of any object seen along any secondary axis of a lens.

Q. What is a positive or real focus?

Ans. A positive focus is the point to which rays are directed after passing through a convex lens, or after reflection from a concave mirror.

Q. What is a negative or virtual focus?

Ans. A negative focus is the point from which rays appear to diverge after passing through a concave lens, or after reflection from a convex mirror.

Q. In what two ways may divergent rays of light be brought to a focus?

Ans. By reflection from a concave mirror of sufficient concavity, or by passing through a convex lens of sufficient strength.

Q. What determines the focal length of a lens?

Ans. Its radius of curvature, the density of the glass and the density of the medium surrounding it.

Q. What is the focal length of a lens?

Ans. It is the distance from the optical center of the lens to its principal focus.

Q. What is the effective difference between a negative lens and a positive lens?

Ans. A negative lens causes light to diverge. A positive lens causes light to converge.

Q. At what distance from any positive spherical lens must an object be placed, to have the image formed at exactly the same distance from the lens?

Ans. At twice its principal focal distance.

Q. What is a parallel?

Ans. It is represented by lines, always the same distance from each other, extended in the same direction, but traveling in separate paths.

Q. What effect has the lens upon light passing through it, along the principal axis?

Ans. None, except that its speed is retarded.

Q. In what direction is a ray of light refracted in passing through a spherical lens?

Ans. Assuming the light to be parallel at the point of incidence, when passing through a convex lens it is refracted toward the optic axis. In passing through a concave lens light is bent or refracted away from the optic axis.

Q. If light passes through a lens, along its secondary axis, what happens?

Ans. It undergoes some slight refraction and is laterally displaced, but continues in the same direction. The refracted ray being parallel to the incident ray.

Q. How is light from a distant source altered in direction, in passing through a plus spherical lens?

Ans. A plus spherical lens causes the light to converge to a real focus.

Q. Through a minus spherical lens?

Ans. A minus spherical lens causes light to diverge from a virtual focus.

Q. If a wave of light enters a lens as a plus four diopter value, and emerges as a minus two diopter wave, what is the character and power of the lens intervening?

Ans. This lens is concave or negative and is —6.00D.

Q. What is meant by conjugate foci?

Ans. Conjugate foci are interchangeable foci in which the

image can be replaced by the object and the object by the image. Two points so situated in relation to each other that the direction of a ray proceeding from either of them after reflection or refraction, passes through the other.

Q. What is the rule for calculating conjugates?

Ans. Subtract the distance of the object in diopters from the dioptric value of the lens, and the remainder will be the distance of the conjugate expressed in diopters.

Q. At what point should a plus eight diopter lens be placed to bring two points twenty inches apart, into conjugate relation with each other?

Ans. The plus eight diopter lens must be placed midway between the two points.

Q. What do you understand by principal conjugate?

Ans. The principal conjugate is one focal length on either side of a plus lens with infinity.

Q. What are symmetrical conjugates?

Ans. Symmetrical conjugates are points on the principal axis, two focal lengths on each side of a plus lens.

Q. What are unclassified conjugates?

Ans. There are an indefinite number of such conjugates for every plus lens which are known as unclassified conjugates. If a normal eye accommodates one diopter, its conjugate plane is at one meter, and for two diopters of accommodation, the conjugate plane is at one-half meter, etc.

Q. Define conjugate foci?

Ans. Conjugate foci are the location in relation to a lens or mirror of the object and its image. When the image is real the two points are directly conjugate. When the image is virtual they are inversely conjugate.

Q. Give rule for finding the conjugate foci, with a positive lens, or mirror, intervening.

Ans. Multiply the principal focal length of the lens or mirror by the distance of the object from the lens or mirror, and divide the product by the difference in distance from the object

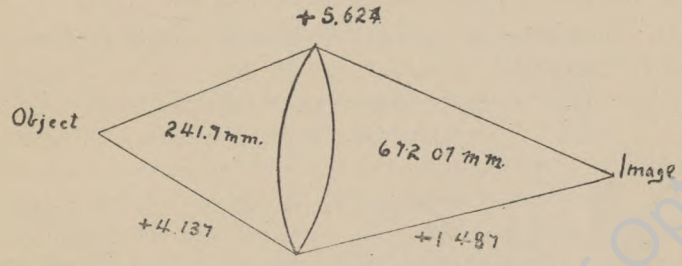
and image to the lens or mirror. The quotient will be the conjugate focal point.

Q. Give rule for finding conjugate foci with a negative lens intervening.

Ans. Multiply the principal focal length of the lens by the distance of the object from the lens and divide the product by the sum of the two distances. The quotient will be the negative conjugate focal point.

Q. A concave mirror has a principal focus of twelve inches. A candle flame is placed sixty-two inches in front of the mirror. Find the conjugate focal point.

Ans. By applying the rule we would find it thus, $12 \times 62 = 744 \div 50 = 14.88$ inches, which would be the conjugate focal point, located on the same side of the mirror.



Q. How far from a 7-inch bi-convex lens must an object be placed in order to produce a conjugate foci, so that the object and image will be exactly 36 inches apart?

Ans. Thirty-six inches equals 914.4 mm. The lens has a principal focus of 177.8 mm. and a dioptric value of +5.624.

Optics

Q. Define optics.

Ans. Optics is the science of light, and the functions of the organs of vision.

Q. A candle flame is placed thirty-six inches from a positive six-inch spherical lens. Find the conjugate focal point.

Ans. $36 \times 6 = 216 \div 30 = 7.2$ inches, on the opposite side of the lens, which would be the conjugate focal point.

Q. A candle flame is placed 15 inches from a concave spherical lens whose principal focus is nine inches. Locate its conjugate focal point.

Ans. This would be a negative conjugate focal point situated 5⅝ inches on the same side of the lens. Thus $15 \times 9 = 135 \div 24 = 5\frac{5}{8}$ inches negative.

Q. What relation have the symmetrical conjugate foci to the principal focus of a lens?

Ans. They are twice as far from the lens as the principal focus.

Q. A convex spherical lens has a principal focus of eighteen inches. A candle flame is placed 30 inches from the lens. Locate its conjugate foci.

Ans. Its conjugate point would be at 45 inches on the other side of the lens. Thus: $18 \times 30 = 540 \div 12 = 45$ inches.

Q. In what way is the principal of conjugate foci put to use in optometry?

Ans. Whenever we have rays of light starting from a certain place and we wish to bring them to a focus at another—for example, in direct ophthalmoscopy and retinoscopy.

Q. If an object is placed 12 inches in front of a plus lens whose focal length is 6 inches, where would the image be, and what are the two points called?

Ans. The image would be at 12 inches on the opposite side of the lens. The two points are called symmetrical conjugate foci.

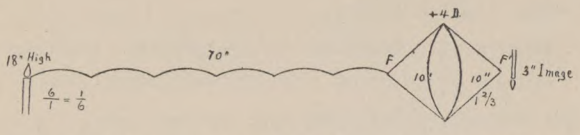
Q. A candle flame 12″ high is placed 56″ from a minus 5 D. spherical lens. Locate the image and calculate its size by focal lengths.

Ans. The principal focus of a —5 D. lens is 8″, negative which we designate as F^1; eight inches on the opposite side of the lens is also a focal point; therefore, we designate it as F. The

number of focal lengths are always calculated from F to the object which would be 64 inches or eight focal lengths, the reciprocal of 8/1 equals ⅛, which tells us the size and location of the image. The image would appear to be ⅛ the size of the object, or 1½ inches high, and located ⅛ of a focal length or 1 inch posterior to F′ located seven inches in front of the lens, and would be a virtual image.

Q. A candle flame 18 inches high is placed 70 inches from a plus 4 D. spherical lens. Locate the image and calculate its size by focal lengths.

Ans.



The principal focus of a 4 D. lens is ten inches, which is designated as F′; ten inches towards the object is also a focal point; therefore, we designate it as F. Now we always calculate the number of focal lengths from F. There being ten inches in a focal length, we would have 60 inches or six focal lengths from F to the object, the reciprocal of 6/1 equals 1/6, which tells us the size and location of the image. The image would be 1/6 the size of the object, or three inches high, and located 1/6 of a focal length. Posterior to F′, or 1⅔ inches, which would be 11⅔ inches from the lens, and would be a real inverted image.

Q. What is a catoptry? Dioptry?

Ans. The unit of reflective power of curved mirrors. A catopter mirror will reflect parallel rays of light to a focus at a distance of one meter or 40 inches. A diopter is the unit for expressing the refractive power of a lens or prism. The power of a lens which will focus parallel rays of light at one meter. A one diopter prism will bend light one cm. in one meter distance.

Q. Why does a stick appear as though bent when placed partly under water?

Ans. Light travels in straight lines, and the object appear-

ing in the direction of the refracted ray causes the appearance. The light reflected from the stick under water is refracted at the surface, causing the apparent displacement.

Q. What is a shadow?

Ans. An effect of intercepted rays of light.

Q. What is the umbra and what is the penumbra in a shadow?

Ans. The umbra is that part of the shadow cast by an opaque object where there is no light. The penumbra is the outer border of the shadow which receives some light from the source, yet is in the shadow.

Q. Under what condition do we have the umbra only?

Ans. When the source is extremely small and the opaque body large.

Q. Under what condition is there produced both the penumbra and umbra?

Ans. When the source of light is large and the opaque body, which casts the shadow, is small.

Q. If a ray of light strikes the mirror obliquely in what direction is it reflected?

Ans. It is reflected obliquely, making the angle of reflection the same as the angle of incidence.

Q. What is a mirror?

Ans. A mirror is a smooth glass, backed by an alloy of 30 parts mercury and 70 parts tin, usually manufactured with a highly polished surface.

Q. What is a plane mirror?

Ans. A plane mirror is one with a flat surface.

Q. How do plane mirrors affect light?

Ans. They simply reverse the waves of light without changing their kind or value.

Q. What is a concave mirror?

Ans. A concave mirror is one whose reflecting surface is concave. Also known as positive or plus mirror.

Q. How do concave mirrors affect light?
Ans. Concave mirrors reflect the light convergently.

Q. What is a convex mirror?
Ans. A convex mirror is one with a convex surface.

Q. How do convex mirrors affect light?
Ans. Convex mirrors reflect light divergently.

Q. What is meant by the focal length of a concave mirror?
Ans. The distance from the principal focus to the mirror.

Q. What effect does a concave mirror have on parallel rays of light?
Ans. The mirror impresses plus on the light reflecting the rays convergently, causing them to focus midway between the center of curvature and the mirror.

Q. What is the formula for calculating the size of images?
Ans. The size of the object is to the size of the image as the distance of the object is to the distance of the image.

Q. A tree 50 feet away forms an image 4 mm. in height on the retina of an eye, which is hyperopic 3.00 D. What is the actual height of the tree? Give calculation.
Ans. Consider the eye underdeveloped 1 mm., as a shortening of ⅓ mm. from nodal point of retina creates about 1.00 D. of hyperopia, taking the emmetropic eye of 15 mm. as the standard. We have then in the problem a distance of 14 mm. from nodal point to retina. Reducing distance of tree to millimeters, $50\times 300=15000$. Now, using the formula,

$$\frac{\text{Size of image} \times \text{distance of object}}{\text{Distance of image}} = \text{Size of object}$$

we have $\frac{4\times 15000}{14}=4282\frac{5}{7}$ mm. height of tree.

Q. Which makes the largest image, a +3.00 D. lens or a +6.00 D. lens with object 19 feet?
Ans. The +3.00 D. lens makes the largest image.

Q. What is an image?

Ans. A picture or conception of anything real. A duplicate or likeness of the object.

Q. How many kinds of images are there?

Ans. Two—Real and virtual.

Q. What is the difference between a real image and a virtual image?

Ans. Real images can be thrown on a screen, and are true images. Virtual images are imaginary.

Q. By what do we judge the size of objects?

Ans. By the size of the image on the retina and the apparent distance the object is away from the eye.

Q. +2.00 Sph⊂+1.00 Cyl. Ax 90. At what distance from this lens will the image of a distant point have the form of a vertical line? At what distance will the image be a horizontal line?

Ans. Transposing to a cross cylinder, we have +2.00 Cyl. Ax. 180 ⊂+3.00 Cyl. Ax. 90. As a cylinder brings light to a focus in the form of a line parallel with the axis, the +3.00 Cyl. will form a vertical line at 33⅓ cm., while the +2.00 Cyl. will form a horizontal line at 50 cm.

Q. A tree 30 ft. tall is standing 50 yds. from a +4.00 lens. How far from the lens and how tall is the image of the tree?

Ans. Ten inches from lens, 1/6 ft. or 2 inches tall.

Q. A candle flame is placed on the principal axis of a concave mirror at a distance of 160 cm. and its image is formed at 40 cm. What is the radius of curvature of the mirror?

Ans. Value of wave which falls on the mirror coming from the light at 160 cm. equals 100/160=.625 D., and being divergent is minus. Value of wave forming the image at 40 cm. equals 100/40=2.5 D. and being convergent is plus. Subtracting power of incident wave (—.62) from power of emergent wave (+2.5), we have +3.12 for the power of the mirror. Focal length equals 100/3.12=32 cm. Since focal length of a mirror equals ½ its radius of curvature, then radius of this mirror equals 2×32=64 cm.

Q. What must be the height of a vertical plane mirror in order that a man 6 feet tall standing 2 inches in front of it may see a full length image of himself? What will be the nature of the image?

Ans. It will be an erect virtual image. The right side of the image corresponds with the right side of the object and the left side of the image with the left side of the object, although it is frequently stated that where a man stands in front of a mirror the right side of the image shows the left side of the object, and that if the man extends the right hand the image extends the left hand. The true explanation of this so-called "perversion" of the image in a plane mirror, that whereas up and down remain unchanged in the image of an object in a plane mirror, right and left reversed, is probably because a person regarding his image under such circumstances is unconsciously disposed to transfer himself mentally to coincidence with his image by a rotation of 180 degrees not around a horizontal axis, but around a vertical axis, thus producing a confusion of mind as to right and left, but not top and bottom. The reason for this is probably due to the fact that the vertical rotation can be easily executed in reality, and partly to the fact that the body is nearly symmetrical with respect to a vertical plane. The mirror must be three feet in height. The plane mirror makes no change in the visual angle, neither increasing nor decreasing the divergence of the days, but merely reversing their direction.

Q. What is the effect when viewing an object in a convex mirror?

Ans. The image will be erect and appear smaller and farther away.

Q. Why does a virtual image, formed by a plane mirror, appear to be as far back of the mirror as the object is in front of it?

Ans. The mirror doubles its distance, as the eye instead of receiving rays from the object, receives reflected rays. The light traversing the space between the object and the mirror and back again to the eye. Therefore, the location of the image appears to be double the distance.

Q. Is it possible, with a concave mirror, to get an inverted image the same size as the object?

Ans. Yes. Place the object at the center of curvature.

Q. With a +4.00 lens the image is ¼ the size of the object. Find the distance from object to image.

Ans. Since size of object bears the same ratio to size of image as distance of object from lens bears to distance of image; then in this problem distance of image equals ¼ the distance of object. Since focal length and dioptric power are inversely proportionate, then

Let x = Dioptric value of incident wave.
4x = Dioptric value of emergent wave.
5x=Power of lens, +4.00.
5x=4.00

$$x=\frac{4.00}{5}=.80$$ D. value of incident wave which, traveling from the object to lens, we consider as minus. Then distance of object equals 100/.8=125 cm.

4x = 4×8 3.2 D., value of emergent wave, which is convergent or plus. Then distance of image=100/3.2=31.2 cm. Therefore distance of object to image=125+31.2=156.2 cm.

Q. A concave mirror has a principal focus of 18 inches. Where must the object be placed in order to produce a virtual image four times as far from the mirror?

Ans. The mirror would be a +2.2222 C.

Let x = the emergent wave.
3x + x = the incident wave.
x = .6405 emergent wave.
3x = 2.2222.

Then 3x+x= -2.9627 incident wave.

The object must be placed 337.5 mm. from the pole of the mirror, then the image will appear to be 1350 mm. behind the mirror, and be four times as far away.

Q. An object 5 cm. high is 50 cm. from a concave mirror of

a focal length of 30 cm. Where is the image, and what is its size? Give radius of mirror.

Ans. A distance of 50 cm. is equivalent to 2.00 D. the focal power of the mirror is 3⅓ D. This leaves the emerging wave 1⅓ D. convergent or plus, which equals a focus of 75 cm. The object being at 50 cm. and its image at 75 cm. The size of object will be ⅔ that of image which can be found by the following proportion.

5 :x : :50 :75=7.5 cm. Size of image.

The radius of the mirror is twice its principal focal length which would be 2×30 cm.=60 cm.

Q. The focal length of a convex lens is 20 cm. and an object is placed 100 cm. in front of the lens. Where will the image be and will it be erect or inverted?

Ans. The lens would be a +5.00 D., and focus at 10 inches or 25 cm. The image would be real and inverted.

Q. A convex lens has a focus of 6⅔ inches. A light is placed before it and a real image 4 inches high is formed at 100 cm. from the lens. What is the height and distance of the light?

Ans. Power of the lens equals $\frac{40}{6\frac{2}{3}}$=6.00 D. Value of the emergent wave forming a real image at 100 cm. = +1.00 D. Subtracting the power of the lens from this we get -5.00 for the value of the incident wave from light to the lens. The light is therefore 8 inches from the lens. By multiplying the size of image by distance of object, and dividing result by distance of the image we get the size of the object $\frac{4\times8}{40\text{ in.}}=\frac{32}{40}=\frac{4}{5}$ ins., height of light.

Q. A concave mirror has a radius of 40 cm. How far would you place an object from it to get an inverted image at 50 cm.?

Ans. Focus of the mirror equals ½ the radius of 20 cm., 100/20 =5.00 power of mirror, which is plus, since its focus is positive. In order to get a real inverted image at 50 cm. we must have a +2.00 wave emerging from the mirror. Subtracting the

power of mirror (+5.00) from the emergent wave (+2.00) we got -3.00 for the value of the incident wave. The object must therefore be placed 13⅓ inches from the mirror.

Q. How tall is a tree 500 ft. away if the image formed by a +10. D. lens is one inch high?

Ans. Rays of light coming from the tree strike the lens as parallel and the image is formed at the principal focus of the lens or four inches. Using the formula:

$$\frac{\text{Height of image} \times \text{distance of object}}{\text{Distance of image}} = \text{Height of object.}$$

We have $\frac{1 \times 6000 \text{ in.}}{4 \text{ in.}} = 1500$ ins. or 125 ft., height of tree.

Q. A candle flame is placed 40 cm. from a plus 1.50 D. lens, 12 inches beyond the lens is a minus .75 D. Where will the light focus?

Ans. The wave will strike the first lens as a —2.50 value, and leave it as a —1.00 wave and focus negative 40 inches. Then will arrive at the second lens as —.75 value, and emerge as a minus 1.50 wave, and focus negative at 68.85 cm. or about 27 inches.

Q. The principal focus of a convex mirror is 30 cm. Locate the image of an object placed 10 cm. in front of the mirror.

Ans. The mirror would have a radius of 60 cm. or 24 inches and would be a minus 3⅓ C mirror. The wave would strike the mirror as —10.00 D., and leave as minus 13⅓ value and focus negative at 3 inches.

Q. A +2.00 lens is placed 10 cm. in front of a +2.50 D. What is the power of the combination?

Ans. The +2.00 starts the rays towards a focus 50 cm. from it, +2.50 at 10 cm. receives the rays on their way to a focus 40 cm. from it, which equals +2.50 D., adding +2.50 makes a total of 5.00 D. With a focal length of 20 cm. adding the 10 cm. between lenses we have 30 cm. as the focal length of the combination which equals a dioptric value of 3.33⅓ D.

Q. An object is 80 inches from a convex mirror. The image is formed 10 inches from the mirror, and is 2 inches high. What is the size of the object and radius of the mirror?

Ans. Apply the rule, $\times : 2 :: 80 : 10 \quad \frac{2 \times 80}{10} = 16$ inches, size of object, or power of emergent wave, times size of image, divided by power of incident wave $4 \times 2 = 8 \div 50 = 16$ inches, size of object. Radius equals twice the principal focal distance which would be 22.85 inches. Value of incident wave —.50 focus at 10 inches negative would equal —4.00 emerging wave, therefore the mirror must be —3.50 C., with a principal focus of 11.428 inches, double the focus equals radius of mirror.

Q. What dioptral power of accommodation, will the normal eye have to exert, in order to view its own image in a concave mirror of 32 cm. radius, when the eye is 8 cm. from the mirror?

Ans. The mirror would be a plus 6.25 C. The wave would strike the mirror as —12.50 and leave as —6.25, and focus negative or behind the mirror 16 cm., so the eye would see its image at 24 cm. away, which would require 4.1666 Diopters of accommodation.

Q. An object 5 cm. high is 50 cm. from a concave mirror of a focal length of 30 cm. Where is the image and what is its size?

Ans. The mirror would be $+3\frac{1}{3}$ C. The incident wave would be —2.00 value and emerge from the mirror as $+1\frac{1}{3}$ wave, and focus at 30 inches. The image would be 3 inches high and be real and inverted.

Q. An object is placed 5 inches from a convex lens whose focal length is 10 inches. Find the position of the image and its magnification. Is the image real or virtual?

Ans. The incident wave would be —8.00 D. The lens being +4.00 D. The emergent wave would be —4.00 D., and focus negative, 10 inches. The image would be virtual and twice the size of the object.

Q. A candle flame is held 10 inches from three mirrors, one plane, one convex and one concave. The radius of curvature of

the curved mirrors is 40 inches. Find the distance from the object to the image in each case.

Ans. With plane mirror, the image would appear to be 10 inches behind the mirror, therefore, the distance from object to image would be 20 inches. With convex mirror the image would be 6⅔ inches behind the mirror, making the distance from object image 16⅔ inches. With concave mirror the image is located 20 inches behind the mirror, therefore the distance between object and image would be 30 inches.

Q. If a +8.00 D. lens is placed one meter from a candle flame, state where screen should be placed to receive a perfect image of the flame.

Ans.—The light coming from the candle is made parallel by 1.00 D. of the 8.00 D. lens, thus leaving 7.00 D. to converge the parallel light to a focus. A 7.00 D. lens has the power of bringing parallel light to a focus at 143 mm.

Q. Where must an object be placed, to obtain a real image four times the size of the object, using a +2.50 D. sphere?

Ans. The object must be placed 20 inches from the lens. Then the image would be four times as far from the lens, therefore would be four times as large.

Q. How do we know whether an image is real or virtual?

Ans. If the rays cross each other the image is said to be real. If they do not, the image is virtual.

Q. How do the images created by concave mirrors vary with the position of the object reflected?

Ans. If the object be situated between the principal focus and the mirror, the image is virtual, not inverted, magnified and located behind the mirror. If the object be situated between the principal focus and the center of curvature, the image is real, magnified, inverted and located beyond the center of curvature. If the object be situated beyond the center of curvature, the image is real, smaller than the object, inverted and located between the principle focus and the center of curvature. If the object be situated exactly at the center of curvature the object and the image are located at the same place.

Q. When an object is located at a point from a concave mirror equal to its radius, where will the image be formed?

Ans. At the same place.

Q. At one meter from a candle flame place a plus five diopter lens. At 20 cm. farther is placed a minus 10.00 D. lens. Where will the wave of light focus?

Ans. The rays will arrive at the first lens as a minus one wave and emerge as plus four diopter and will leave the second lens as a plus ten diopter wave and focus at four inches, behind the lens.

Q. A candle flame 20 cm. in front of a lens forms an image on a screen 60 cm. beyond the lens. What is the dioptric power of the lens?

Ans. The incident wave would be minus five diopters. The emergent wave would be plus 1.66⅔ D. Therefore the power of the lens must be plus 6.66⅔ D.

Q. A concave mirror has a principal focus of 18 inches. Where must the object be placed in order to produce a real image four times the size of the object?

Ans. To have a principal focus at 18 inches requires 2.2222 D. power. Then the mirror is a plus 2.2222 C. To find the location of the object and image we

Let $x =$ the emergent wave.
$4x =$ the incident wave.
$5x = +2.2222$
$x = +\ .444.$

Then $4x = 2.2222$ minus $.4444 = -1.7778$ incident wave. The object must be placed 562.5 mm. from the pole of the mirror. Then the image will be 2250.2 mm. from the mirror, and be four times as large.

Q. A plane mirror is placed at the bottom of a tank of water face up. The water is one meter deep. An object is held ½ meter from and parallel to the surface of the water. How far will the image appear to be from the object?

Ans. The image will appear to be 2⅓ meters from the object.

Q. What is the effect, when viewing an image in a concave mirror, when the observer is beyond the focal point of the mirror?

Ans. The image will be inverted and enlarged.

Q. Why is it possible to form images, with a pinhole, on a screen?

Ans. Because the pinhole only allows the axial ray from every point of the object to pass to the screen.

Q. A plus four diopter lens is held 40 inches from a candle. Give distance and character of the image.

Ans. The image will be located 13⅓ inches on the other side of the lens. It will be a real inverted image.

Q. Radius of curvature of a concave mirror is 40 cm. Object is 10 cm. from the pole of mirror. Find the distance from the mirror to image and size of image if object is 5 mm. high. Also state whether image is positive, virtual, inverted or erect.

Ans. Distance from mirror to image is 20 cm. or 8 inches. Size of image is 10 mm. It would be an erect virtual image.

Q. When is the real image formed by a concave mirror smaller than the object?

Ans. When the object is situated beyond the radius of the mirror.

Q. Name two optical agents by which parallel rays of light may be made to converge to a real focus.

Ans. The convex spherical lenses and the spherical concave mirrors.

Q. What is the effect on the size of the retinal image when a concave lens is placed within the anterior focus of the eye?

Ans. It is made slightly larger.

Q. A concave mirror, with a focal length of 10 cm. is to produce an erect image 4 cm. square of an object 2 cm. square that is placed before the mirror. At what distance from the mirror must the object be placed? How far behind the mirror is the image?

Ans. The mirror being a +10 cm., the object must be placed 2 inches in front of the mirror. The image would appear to be

four inches behind the mirror, and be twice the size of the object or 4 cm. square.

Q. A candle flame is placed 16 inches from a plus 3.50 sphere. Where will the image be formed?

Ans. Light coming from 16 inches will arrive at the lens as a —2.50 wave and emerge as a +1.00 value and focus at 1 meter.

Q. A candle flame is held 50 cm. from +4.00 D. sphere. Where will the image be formed on the opposite side?

Ans. The image will be formed 50 cm. or 20 inches on the opposite side of the lens.

Q. If a candle flame be placed five inches from a concave mirror whose radius of curvature is 10 inches, where will the image be formed?

Ans. The image will be formed 5 inches behind the mirror. Five inches being the principal focus of the mirror. The rays of light would leave the mirror as parallel and the effect of the mirror for that point would be the same as a plane mirror. The image would be virtual. Same size and same distance from the mirror.

Q. What is the radius of curvature of a concave mirror that focuses parallel light at 34 inches?

Ans. Sixty-eight inches.

Q. What distance will parallel rays be focused by a concave mirror whose radius of curvature is 19 inches?

Ans. The parallel ray will focus at 9½ inches. In concave mirrors the principal focus is always equal to one-half of the radius.

Q. At what distance will parallel rays of light be focused by a concave mirror whose surface has a radius of curvature of 40 cm.?

Ans. The focus will be at 8 inches or 20 cm.

Q. At what distance will parallel rays of light be focused by concave mirror whose radius of curvature is 50 cm.?

Ans. The principal focus of a concave mirror is one-half

its radius; hence a concave mirror with 50 cm. radius of curvature will have a principal focal length of 25 cm.

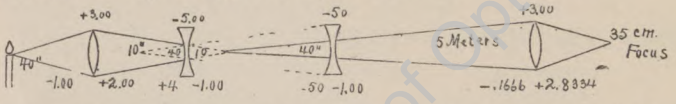
Q. Suppose a concave mirror has a radius of curvature of 10 inches and a lighted candle is placed 20 inches from the mirror, where will the image be formed?

Ans. Radius 10 inches, power of mirror 8 C. One-half of radius equals the focus 5 inches, focus into the unit 40 equals power, a +8.00 D. wave coming from 20 inches would arrive at mirror as —2.00 D. and leave as +6.00 D. and focus at 6⅔ inches.

Q. An image 4 inches high is formed 10 inches from a concave mirror whose radius of curvature is 16 inches. What is the distance and size of object?

Ans. Radius of 16 inches equals +5 C. mirror. The wave coming in must be a —1.00, as it leaves as +4.00 D.; so the distance of the object is 40 inches. Apply rule x:4::40:10=160÷10=16 inches, size of object.

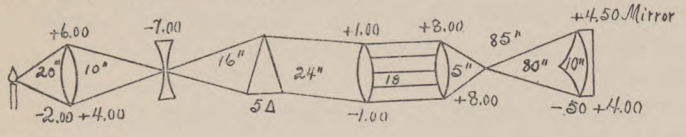
Q. Forty inches from a candle flame is a plus three diopter lens; ten inches farther is placed a minus five diopter. Forty inches from this a minus .50 D. lens is placed. Thence 5 meters to a plus three D. lens. Where will the light from the candle flame focus after passing through this series of lenses?



Ans. The focus would be about 35 cm. beyond the last lens. Light traveling six meters is usually considered as parallel, but in close figuring we find that it has a slight divergence, equal to minus sixteen hundredths of a diopter, which makes a difference of about two centimenters in the location of the image.

Q. A candle flame is placed an unknown distance from a +6 D. lens and produces a positive focus ten inches beyond, at which distance a —7.00 D. lens is placed; thence 16 inches to a five diopter prism, base down; then an unknown distance to a +1.00 D. lens, the wave arriving at this lens as a minus 1.00 D. value; thence 18 inches to a lens of unknown value, which produces a positive focus at 5 inches. A concave mirror is placed at

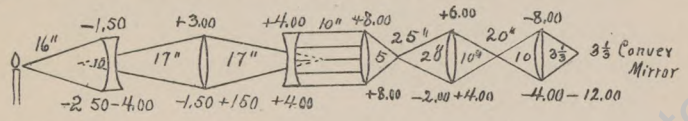
an unknown distance in the path of this wave of light the radius of curvature of the mirror is 444.44 mm. and the wave at the point of incidence has a radius of 2,000 mm. Find all unknown values and locate the image.



Ans.

The image would be located 10 inches in front of the mirror and would be inverted.

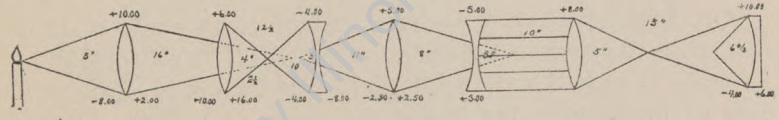
Q. A candle flame is placed 16 inches from a —1.50 lens, then a space of 17 inches, then a +3.00, then 17 inches, then —4.00, then 10 inches, then +8.00, then 25 inches, then +6.00, then 20 inches, then a convex mirror with a radius of 10 inches. Trace the light through the above series of lenses and locate the image. State whether image will be real or virtual.



Ans.

The image will appear to be 3⅓ inches behind the mirror and would be a virtual image.

Q. A candle flame is placed 5 inches from a plus 10 D. lens, then a space 16 inches, then a +6.00 lens, then 12½ inches, then a —4.00 D. lens, then 11 inches, then +5 D. lens, then 8 inches, then —5.00 D. lens, then 10 inches, then +8.00 lens, then 15 inches, then a concave mirror, radius 8 inches. Trace the light through the series of lenses and locate the image. State whether real or virtual.



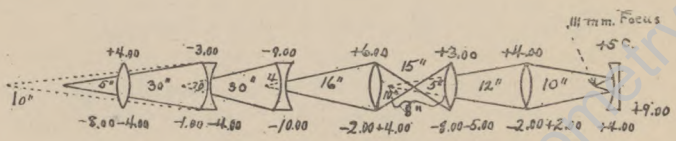
Ans.

The candle flame located 5 inches in front of the first lens,

and the focal point 6⅔ inches in front of the mirror, may be considered conjugate; the image would be real and inverted.

Q. Starting with a negative focus 10 inches in front of a +4.00 D. lens, another lens of unknown value 30 inches beyond also produces a negative focus at 10 inches, a —9.00 D. lens is placed at an unknown distance from the second, and it again produces a negative focus at 4 inches. The fourth lens is 16 inches from the third and is a +6.00 D. The fifth lens is a +3.00 D. and is of unknown distance from the fourth and produces a negative focus at 8 inches. The sixth lens is 12 inches from the fifth, and is of unknown value, and produces a +2.00 D. emergent wave. Ten inches from the sixth lens is placed a concave mirror and produces a positive focus of the wave at 111 mm. Find all unknown values.

Ans.



Angles

Q. If the angle of incidence is 24 degrees with the perpendicular, what will be the angle between the incident and reflected ray?

Ans. The angle between the two will be 48 degrees.

Q. The angle of incidence equals 50 degrees. The index of refraction of the glass equals 1.60. Find the angle of refraction.

Ans. Rule: The angle of incidence is to the angle of refraction as the index of the glass is to the index of air. Thus 50 : X :: 160 : 100=31.25 degrees, angle of refraction.

Q. Light falls on a polished surface at an angle of 37 degrees, with the surface. At what angle will it be reflected?

Ans. The law is that the angle of reflection is equal to the angle of incidence. Therefore, the angle or reflection in this case will be 37 degrees.

Q. What is the critical or limiting angle of refraction?

Ans. This is the angle of incidence which just permits rays of light in a dense medium to pass out into a rare medium. The size of the critical angle depends upon the density of different substances. Light passing from water into air which forms an angle of 48° 35′ with the surface of the water will be refracted and pass out of the water, skimming its surface. But rays which form an angle greater than 48° 35′ will not pass out of the water, but will be totally reflected back into it. The surface separating the two media acts as a plane mirror, becoming a reflecting surface. The critical angle of flint glass is 37° 36′; crown glass, 40° 39′; glass, 41° 38′.

Q. Give formula for finding the critical angle.

Ans. The sine of this angle is the reciprocal of the absolute index of the substance in question; therefore, to find the critical angle of glass whose index is 1.523: $\frac{1}{1.523}$ = .65650 sine of critical angle. From table of sines .65650 is the sine of 41° 49′. Water index 1.33:

$$\frac{1}{1.33} = .7520 = 48° \ 35'$$

Q. Give table of indices of various mediums.

Ans.

Air	1.000294 usually figured as 1.00.
Ice	1.31
Water, distilled	1.33⅓
White of egg	1.351
Turpentine	1.47
Alcohol	1.366
Cornea	1.33⅓
Vitreous Humor	1.33⅓
Aqueous Humor	1.33⅓

Canada Balsam	1.523	Increases about .013 after hardening.
Sea Salt Solution	1.375	
Crown Glass	1.523	Varies.
Flint Glass	1.623	Varies.
Rock Crystal	1.562	
Cinnamon oil	1.60	
Crystalline lens	1.43+	
Diamond	1.47 to 2.70	Varies.

Q. What is meant by "Optical Density?"

Ans. Optical density differs from mere compactness, in referring to the resistance offered by transparent mediums, to the passage of light through them, as compared with air.

Q. What is meant by index of refraction?

Ans. The index of refraction is the refracting power or density of a transparent substance compared with the refracting power of some other substance taken as a standard.

Q. What is meant by relative index and how is it found?

Ans. Relative index is the expression of refractivity when light passes from one dense medium into another as from the Aqueous humor into the Crystalline lens or vice versa. It is found by dividing the index of the medium into which it passes by the index of the medium from which it proceeds.

Example: Index of Crystalline lens divided by the index of the Aqueous humor; 1.43÷1.33=1.075188 Relative index.

Q. What do you understand by absolute index of refraction?

Ans. By absolute index is meant the density or refractive power of any substance as compared with a vacuum.

Q. If the index of refraction of crown glass is 1.50, and, that of flint glass 1.62, what is their relative index?

Ans. To find the relative index in this case, we divide 1.62 by 1.50, which gives 1.08 as the relative index.

Chapter II

ANATOMY OF THE EYE

Q. What is the eye?

Ans. The eye is the peripheral organ of vision.

Q. Name the tunics of the eyeballs.

Ans. First, sclerotic and cornea; second, choroid, cicilary body and iris; third, the retina.

Q. What is the shape of the eyeball?

Ans. The eye-ball is spheroidal in form, with the segment of the smaller sphere projecting from its anterior surface.

Q. At what age is the eyeball fully developed?

Ans. The full size of the eye is not reached until about twenty years of age.

Q. What is the weight of a fully developed eye?

Ans. The average weight of an eye is about ninety-five grains.

Q. Name the chambers of the eye and tell with what they are filled.

Ans. The anterior and posterior chambers are filled with a watery fluid called the aqueous humor. The Hyaloid chamber is filled with a jelly-like substance called the vitreous humor.

Q. Name the layers of the cornea.

Ans. From without inward; the layers of the cornea are the conjunctiva epthelium, Bowman's membrane, cornea proper, membrane of Descement and the endothelium.

Q. Are there any blood vessels in the cornea?

Ans. Normally it is free from blood vessels, but in a diseased or injured condition, the cornea becomes invaded with small blood vessels, which usually impairs vision.

Q. Is the cornea well supplied with nerves?

Ans. Yes. It is the most sensitive portion of the external eye. Its principal nerve supply is derived from the ciliary nerves.

Q. From what source does the cornea receive its nourishment?

Ans. The cornea in health, is devoid of blood vessels, except near its margin. All the remainder of the cornea receives its nourishment from a transparent fluid (Plasma) which circulates through the lymph spaces and channels of the cornea.

Q. Give dimensions of the cornea.

Ans. The cornea is about eleven millimeters in its vertical diameter, and twelve millimeters in its horizontal. It is thicker at its border than at the center, being about one and one-tenth to one and two-tenths millimeters at its border and one millimeter at its center.

Q. Describe the cornea.

Ans. The cornea forms the anterior one-sixth of the eyeball. It is a transparent circular membrane. It has an index of refraction of 1.33⅓, a normal radius of 7.8 mm. on its anterior surface, and a radius of 6.5 mm. on its posterior surface. Its vertical diameter is 11 mm. and its horizontal diameter is 12 mm. It is free from blood vessels except along the border of the sclerotic. It is well supplied with nerves and is composed of five layers.

Q. What is the approximate length of the eyeball, in adults?

Ans. The approximate length of the eyeball from front to back is twenty-four millimeters.

Q. What do you understand by meridian, with reference to the eye?

Ans. Meridian of an eye would mean any straight line beginning and ending in the periphery of the cornea and passing over its anterior pole.

Q. What is the Optic axis of the eye?

Ans. The optic axis of the eye is an imaginary line upon which lie the centers of curvature of the cornea, crystalline lens and retina.

Q. What is the yellow spot of the eye?

Ans. The yellow spot of the eye is the macula lutea, that part of the retina which is most sensitive to form vision.

Q. Name the structures of the eyelids.

Ans. The structures of the eyelids from without inward are—skin, subcutaneous areolar tissue, fibers of the orbicularis muscle, tarsal plates, fibrous membrane (tarsal ligament), meibomian glands, vessels and nerves, and conjunctiva.

Q. What are the orbits?

Ans. The orbits (two in number) are situated in the upper and anterior part of the skull. The orbit is the bony socket for the eye-ball, conical in shape, one and one-quarter inches vertically, one and one-half inches horizontally, and about one and three-quarters inches deep.

Q. Name the bones of the orbit and tell what three enter into the formation of both orbits.

Ans. There are seven bones in each orbit, and eleven bones enter into the formation of both orbits, as follows: Frontal, ethmoid, sphenoid, superior maxillary, molar, lachrymal, and palate. The first three mentioned enter into the formation of both orbits.

Q. What is the orbital opening called?

Ans. The orbital opening is called Aditus Orbitae.

Q. Name the openings of the orbit.

Ans. There are nine openings communicating with each orbit—namely, the optic foramen, the spheno-maxillary fissure, sphenoidal fissure, supraorbital foramen, anterior and posterior ethmoidal foramina, infraorbital foramen, malar foramen, and the canal for the nasal duct.

Q. Tell what passes through each of the nine openings of the orbit.

Ans. The optic foramen transmits the optic nerve and opthalmic artery. The sphenoidal fissure transmits the third, fourth, three branches of the ophthalmic division of the fifth, the sixth nerve and the ophthalmic vein. The spheno-maxillary fissure transmits the superior maxillary nerve and its orbital branches. The infraorbital nerves and vessels and the ascending branches from the spheno-palatine ganglion. The supraorbital foramen transmits the supraorbital artery, nerve and vein. The

anterior themoidal foramen transmits the anterior ethmoidal vessels and nasal nerve. The posterior ethmoidal foramen transmits the posterior ethmoidal vessels. The infraorbital canal transmits the intraorbital vessels and nerve. The molar foramen transmits temporal and molar branches of orbital nerve. The nasal duct transmits the tears to the nose.

Q. Name the three openings at the apex of the orbit.

Ans. The optic foramen, sphenoidal fissure and sphenomaxillary fissure.

Q. Give the arrangement of the bones forming the orbit.

Ans. The floor of the orbit is formed by the superior maxillary, malar and palate. The inner wall is formed by the ethmoid and lachrymal. The roof is formed by the frontal and sphenoid and the outer wall is formed by the malar and sphenoid.

Q. Describe the crystalline lens.

Ans. The crystalline lens is made up of three distinct lenses, enclosed in separate capsules. These lenses as yet have no classic name, but are known from without inward as the sinile lens, which forms before the age of 27 years, inside of which is the juvenile lens; on its surface is the letter Y, upright on the anterior and inverted on the posterior surface. The demarcation of the Y has a salt and pepper appearance, which is denser. Inside of the juvenile is the embryonic lens enclosed in its capsule. The crystalline lens is a transparent body, classed as bi-convex, resting in the Hyaloid Fassa at the anterior surface of the vitreous humor and is supported by the suspensory ligaments. In youth the lens substance is soft and highly elastic, but gradually the central portion hardens, and, as a result of age, forms the nucleus. This hardening results in the loss of accommodation, which is made manifest by uncomfortable near vision. The lens measures about eight millimeters in its transverse diameter and about three and one-half millimeters in thickness. The lens substance is enclosed in a highly elastic membrane known as the lens-capsule. It has a normal radius of ten millimeters on its anterior surface and a radius of six millimeters on its posterior surface, in a state of rest. The lens substance is composed of layers, resembling the layers of an onion, known as

the lens fibers, which are united by a cement substance. Its index of refraction is 1.43+ and it has a dioptric value of about twenty diopters of plus when in a state of rest.

Q. Describe fully the function of the crystalline lens.

Ans. The function of the crystalline lens is to increase and decrease in convexity, and thus provides for focusing upon the retina the rays of light reflected or proceeding from objects situated at different distances. During the act of accommodation the lens takes on more convexity, especially upon its anterior surface, as this is the direction of least resistance. This increase in convexity is brought about by the action of the ciliary muscles acting upon the suspensory ligaments, which encircle the lens, drawing forward the inner layers of the choroid, hyloid membrane and crystalline lens. Thus the lens becomes more convex by its own elasticity.

Q. From what source does the crystalline lens receive its nourishment?

Ans. The crystalline lens is devoid of blood vessels and receives its nourishment from the ciliary body.

Q. How is the crystalline lens of the eye held in position?

Ans. The crystalline lens is held in position by a thin membrane, known as the suspensory ligaments. It is circular in form and completely surrounds the lens, the upper edges being attached to the ciliary processes.

Q. What is the normal capacity for changing the power of the crystalline lens at the age of ten? Age sixty?

Ans. The normal capacity for changing the power of the crystalline lens ranges from fourteen diopters at the age of ten years to one diopter at the age of sixty years.

Q. Describe the retina.

Ans. The retina is the third tunic of the eye. It is a delicate, transparent membrane, formed from the fibers of the optic nerve, which are spread out in every direction from the entrance of the optic nerve to the ora serrata. The retina is attached at two points only—at the optic nerve entrance and its anterior border, the ora serrata. The retina is not attached to the choroid, but simply lies on it. It is composed of ten layers.

Q. Name the ten layers of the retina.

Ans. From within outward:

1. Membrana limitans interna.
2. Fibrous layer.
3. Vascular layer.
4. Inner molecular.
5. Inner nuclear layer.
6. Outer molecular.
7. Outer nuclear layer.
8. Membrane limitans externa.
9. Jacob's membrane or layer of rods and cones.
10. Pigmentary layer.

Some authors give an eleventh layer: the Mueller's layer.

Q. What and where is the macula lutea?

Ans. The small depression of the retina which lies directly in the visual axis. It is about 3½ mm. to the temporal side of the center of the optic disc and is a little less than 2 mm. in diameter. There are rods and cones in the macula area, but the cones are very numerous, estimated to be about 250,000 to the square millimeter.

Q. What is the Fovea Centralis?

Ans. The small depression in the center of the macula lutea. It is the most sensitive spot in the retina.

Q. Why does the macula lutea differ from the surrounding portions of the retina?

Ans. There are two factors that contribute to the formation of the macula lutea. First, a thinning of Jacob's membrane at this point. Second, the optic nerve fibers are lacking here; also the diffuse yellow pigmentation limited to this area.

Q. Why is the macula lutea sometimes called the yellow spot?

Ans. Because it is said to turn yellow after death.

Q. What and where is the vitreous humor?

Ans. The vitreous is a transparent, jelly-like mass. Except in highly myopic eyes it is watery. It somewhat resembles the white of an egg and fills the hyaloid cavity. It occupies about four-fifths of the globe. It serves to give shape to the eyeball,

and is enclosed in a thin, transparent membrane known as the hyaloid membrane. It has an index of refraction of about 1.33⅓. The transparent fibers in the vitreous diverge from an area on the hyaloid membrane, corresponding to the posterior surface of the hyaloid fassa. They spread toward the retina over a large portion of the visual field. These fibers are accumulative of vitroid material and are denser than the semi-fluid.

Q. By what is the aqueous humor secreted?

Ans. The aqueous humor is secreted by the ciliary processes and the posterior surface of the iris.

Q. How is the vitreous humor secreted?

Ans. The vitreous humor is not secreted like the aqueous humor, but is an embryonic product, which is formed in the hyaloid cavity at a very early period of foetal life. When a portion of it is lost it is not reproduced, but its place is filled by lymph. This, however, does not cause an appreciable loss of vision.

Q. What is the function of the vitreous?

Ans. The principal function of the vitreous humor is in connection with the aqueous, to hold the choroid, the retina and sclerotic in their respective positions. Were it not for these humors, especially the vitreous, the eyeball would collapse. The vitreous also affords accommodation in aphakic eyes below the presbyopic age.

Q. What is the choroid composed of?

Ans. It is composed principally of blood vessels and dark brown pigment.

Q. Name the layers of the choroid.

Ans. Although the choroid is very thin it is composed of three distinct layers. From the sclerotic inward, lamina fusca, chorio capillaris and lamina vitrea.

Q. Where is the choroid located?

Ans. The choroid lies between the sclerotic and retina and extends from the optic nerve to the ciliary body.

Q. What is the function of the choroid?

Ans. Choroid is said to nourish the retina and vitreous

humor. Also because of its dark color, it absorbs all strong light inside the eyeball.

Q. Describe the blood supply to the choroid.

Ans. The choroid is supplied with blood by the short ciliary arteries from 6 to 12 in number. They enter the eye around the optic nerve to supply the choroid and ciliary processes.

Q. Where is the supra-choroidal space?

Ans. The space between the choroid and sclerotic.

Q. What and where is the choroidal fissure?

The opening in the choroid through which the optic nerve fibers pass.

Q. What is the principal blood supply of the eye?

Ans. The ophthalmic artery supplies the eye with blood. It is a branch of the internal carotid artery.

Q. Where is the anterior chamber? Posterior chamber?

Ans. The anterior chamber is between the cornea and iris. The posterior chamber is between the iris and crystalline lens. These chambers are filled with aqueous humor.

Q. What is the palpebral fissure?

Ans. The palpebral fissure is the opening between the lids through which the eyeball is seen.

Q. Where is the canal of Schlemm, and what is its office?

Ans. A circular canal surrounding the eye at the sclero-carneal junction. From this canal the excess humor passes into the anterior ciliary veins.

Q. What is meant by trochlea?

Ans. The pulley-shaped ring through which the tendon of superior oblique muscle passes.

Q. What is the point of union between the lids called?

Ans. The point of union between the lids is called the palpebral fissure.

Q. Describe the Meibomian glands and give their location.

Ans. They are a number of small glands which are embedded in the tarsal cartilages of the eyelids. There are about 35 in the upper lid and about 25 in the lower lid.

Q. Give the function of the Meibomian glands.

Ans. Their ducts open on the margin of the lids and the glands secrete an oily fluid which acts as a lubricant for the eyeball. It, together with the tears, permits the lids to glide freely over the eyeball. This lubrication on the edges of the lids prevents the normal flow of tears from overflowing their borders, and also prevents the lids from sticking together when they are closed. This oily fluid in combination with the tears thus aids in preventing friction between the eyeball and lids. It also prevents the cornea from drying out so quickly.

Q. Where are Zeiss's glands?

Ans. The sebaceous glands located at the margin of the eyelids.

Q. As what are the glands of Moll regarded?

Ans. The glands of Moll are regarded as enlarged and modified sweat glands.

Q. What is meant by the "Uveal Tract"?

Ans. The second tunic of the eye. It consists of the chroid, ciliary body and iris.

Q. Where is the canal of Stilling?

Ans. The canal of Stilling or hyaloid canal is a canal extending from the entrance of the optic nerve to the lens capsule.

Q. Where is the canal of Schlemm?

Ans. At the sclero-corneal junction, and parallel to the corneal border, but entirely within the structure of the sclerotic.

Q. Describe the sclerotic?

Ans. The sclerotic is the tough, white, outer fibrous coat covering the whole eye, except the anterior portion, occupied by the cornea. It is thickest at its posterior portion and gradually becomes thinner as it approaches the cornea, where it again thickens at the sclero-corneal junction.

Q. What is the function of the sclerotic?

Ans. The sclerotic coat serves to give shape to the eye and protect its more delicate interior. It also offers a firm foundation for the attachment of the tendons of the various extrinsic muscles. It covers the posterior 5/6 of the globe.

Q. Where is the optic disc?

Ans. The optic disc is located about 2.5 mm. nasalward to the antero-posterior axis of the eyeball.

Q. What is the depression in the center of the optic disc known as?

Ans. This depression is known as the physiological cup.

Q. Why is the optic disc sometimes called the blind spot?

Ans. The optic disc is really the head of the optic nerve, and is the only portion of the retina where the sense of vision is wanting. It is, therefore, called the blind spot.

Q. Describe the optic disc.

Ans. The optic disc is usually round or oval in shape, although it may be very irregular in outline. It is about 1.5 mm. in its transverse diameter.

Q. What is the optic papilla?

Ans. The optic papilla is the elevation caused by the optic nerve fibers spreading out in all directions. It is also known as the optic disc, optic nerve head and blind spot. It lies about 3½ mm. on the nasal side of the center of the macula lutea.

Q. Describe a normal fundus.

Ans. The fundus presents an orange-red surface upon which we distinguish the disc, the blood vessels and the macula. The disc is usually circular, but may be oval in form. Its color is light pinkish, more pronounced over the inner half, the outer portion being paler. The disc is much lighter in color than the rest of the fundus. Near the center of the disc is usually seen a depression known as the physiologic cup. The veins are recognized by being larger in size and darker in color than the arteries. The optic disc is about 1.5 mm. in diameter and is situated nasalward from the posterior pole of the eye. The macula lutea is a little less than 2 mm. in diameter. It is oval in shape, with its long diameter horizontal, and is darker in color than the rest of the fundus. At its center is the fovea centralis, which appears as a bright spot.

Q. What is the depression called at the center of the optic papilla?

Ans. The funnel-shaped depression formed by the separation of the nerve fibers is known as the physiological cup.

Q. Are the rods or cones more numerous in the retina?

Ans. The rods greatly predominate in number over the cones, excepting in the fovea centralis, where they are entirely absent.

Q. Are the cones more or less numerous near the ora serrata?

The number of cones decreases rapidly as the outer edge of the retina is approached.

Q. How many rods and cones are there in the human eye?

Ans. Approximately one hundred and thirty million rods and about seven million cones.

Q. Name the three membranes that enclose the humors of the eye.

Ans. The hyaloid membrane, which contains the vitreous humor. The lens capsule, which contains the lens substance and the endothelium, which contains the aqueous humor.

Q. What and where is Bruch's membrane?

Ans. Basales lamina, or membrane of Bruch, is the membrane which separates the choroid from the pigmentary layer of the retina.

Q. What is meant by hyaloid membrane?

Ans. Hyaloid membrane is the transparent sac which contains the vitreous humor.

Q. Where is the membrane of Descemet?

Ans. The posterior limiting membrane of the cornea, the fourth layer from without in.

Q. What is the nictiting membrane or plica semilunaris?

Ans. An undeveloped structure in man, but well developed in various animals, such as birds and fish. It is to be found at the inner canthus and is sometimes called the third eyelid. Its function is to protect the cornea from being exposed to high winds or water.

Q. What and where is Jacob's membrane?

Ans. It is the layer of rods and cones of the retina, being the ninth layer.

Q. What and where is the Capsule of Tenon?

Ans. It is a thin, membranous sac between the eyeball and the wall of the orbit, isolating the eyeball and allowing free movement. It is a very delicate membrane consisting of two layers investing the posterior portion of the eyeball from the ciliary margin of the cornea backward to the entrance of the optic nerve.

Q. Where is Bowman's membrane?

Ans. The second anterior layer of the cornea.

Q. Locate and describe the lachrymal glands and trace the path of the tears.

Ans. The lachrymal glands are the glands which secrete the tears. They are located in a depression of the frontal bone at the upper and outer angle of the orbits. The gland is divided into two parts, the superior and inferior. The secretory ducts, about 10 in number, convey the fluid to the surface of the eye. This fluid after flushing the eye runs through the puncta lachrymalia into the lachrymal canal, then to the lachrymal sac and along the nasal duct into the cavity of the nose and down the throat.

Q. Where are the puncta lachrymalia and what purpose do they serve?

Ans. The puncta lachrymalia are very small openings connecting the front of the eyeball with the cavities of the nose. They carry off the surplus tears that constantly bathe the eyes.

Q.—What is the lachrymal apparatus? Give location.

Ans. The lachrymal gland. Its ducts, the puncta, sac and nasal duct. This system flushes the eye. The lachrymal gland is oval in shape, about the shape and size of an almond, situated in a depression at the upper outer angle of the orbit. The ducts number from 7 to 10.

Q. What is epiphora?

Ans. An overflow of tears, causing them to run over the margin of the lids.

Q. Describe the drainage system of the eye.

Ans. This question may mean a description of the lachrymal apparatus only. If, however, it is meant that a detailed

description should be given, then the manner of passage from the eye, of the venous blood and the vitreous and aqueous humors must be included.

Q. What forms the suspensory ligaments?

Ans. The suspensory ligaments of the crystalline lens are formed by a continuation of the hyaloid membrane, which encloses the vitreous humor.

Q. What and where are the suspensory ligaments?

Ans. The ligaments which are attached to the lens capsule and extend to the ciliary muscles and are delicate membranes.

Q. Describe the Iris.

Ans. The anterior part of the second tunic, at the sclero-corneal junction. A curtain like membrane suspended in the aqueous humor, separating the anterior from the posterior chamber. It is perforated by a circular opening called the pupil, which is constantly varying in size, owing to the contraction of its two sets of muscles.

Q. What is the color of the iris?

Ans. The color of the iris depends upon the amount and tints of the particles contained in its pigment cells, and varies in different individuals. The color of the irises, as a rule, is the same, but there are instances in which there are congenital differences, although they may be perfectly healthy.

Q. Name the muscles of the iris, give their functions and nerve supply.

Ans. The sphincter muscle contracts the iris, which narrows the pupil. Supplied by the third or oculo motor nerve. The dilator muscle widens the pupil, and is supplied by the dilator fibers of the sympathetic.

Q. What are the cilia?

Ans. The eyelashes; short, stiff hairs in from two to four rows at the anterior border of the lids.

Q. What is the function of the cilia?

Ans. The cilia protect the conjunctiva from dust and other foreign substances, and also assist in shutting out stray light.

Q. What is the fornix conjunctiva?

Ans. The turn or fold of the conjunctiva.

Q. Name the refracting media of the eye?

Ans. The cornea, the aqueous humor, crystalline lens and vitreous humor.

Q. What is the conjunctiva of the eye and where is it located?

Ans. The conjunctiva is the mucous membrane of the eye. It covers the anterior surface of the eye, and lines the inner surface of the eyelids.

Q. Which is the longest diameter of the eyeball?

Ans. The antero-posterior diameter is the longest, because of the projection of the cornea.

Q. What are the angles of the eyelids called?

Ans. They are called the outer and inner canthi.

Q. What makes the eyeball a dark chamber?

Ans. The eyeball is a dark chamber because most of the light entering is absorbed by the pigment in the second tunic.

Q. What part of the eye is sometimes called the danger zone?

Ans. The danger zone commences at the junction of the sclerotic and the cornea and extends backwards, one-fourth of an inch. Any affection or injury of this structure is marked by extreme tenderness in this region of the eye.

Q. What are the appendages of the eye?

Ans. The orbits, the eyelids, the eyebrows, the conjunctiva, the lachrymal apparatus, the muscles, the aponeurosis, tenon's capsule, vessels and nerves of the orbit and nasal duct.

Q. Of what is the ciliary body composed?

Ans. The ciliary body is composed of the ciliary muscles and the ciliary processes.

Q. Where is the ciliary body?

Ans. The ciliary body is that portion of the Tunica Vasculosa which lies between the choroid and iris. It is continuous with both and is about one-fourth of an inch in width.

Q. Give number and size of the ciliary processes.

Ans. The ciliary processes number about seventy-two, and are of variable size, the larger of which are about one-tenth of an inch in length.

Q. Describe the function of the eyelids and name the muscles by which it is controlled, and the nerve supply to each.

Ans. The eyelids are two movable folds of tissue, covering and protecting the front of the eye. The upper lid is larger, longer and more movable, being supplied with a special muscle, the levator palpebrae superioris, or lifter of the upper lid, and is supplied by the third cranial nerve. The orbicularis palpebrarum muscle closes the lids, and is supplied by the seventh, or facial, nerve. The muscle of Riolonis in an involuntary muscle used in closing the lid with force, and holds the margin of the lids together more firmly and is supplied by the seventh or facial nerve.

Q. What are the cartilages and their function?

Ans. The framework or skeleton layer of the eyelids. They serve to give firmness and shape to the eyelids.

Q. What is Pettit's Canal?

Ans. The space or canal between the suspensory ligaments.

Q. What is the fundus oculi?

Ans. The fundus of the eye as seen by means of the ophthalmoscope. The retina, optic disc, choroid and blood vessels taken collectively. The back part of the eye viewed through the refractive media.

Q. What and where is the caruncula lachrymalis?

Ans. A small, rounded, reddish body of flesh, at the inner canthus of the eye.

Q. What is meant by episclera?

Ans. The connective tissue between the sclera and the conjunctiva.

Q. What is meant by the Liquor Morgagni?

Ans. A small quantity of fluid between the crystalline lens and its capsule. This fluid prevents friction between the lens and its capsule, as it permits the capsule to glide freely over the surface of the lens during the act of accommodation.

Q. What is meant by Fossa? Follicle?

Ans. Fossa is a pit or depression. Follicle is a small secretory cavity or sac.

Q. What is the lamina cribrosa?

Ans. The sievelike perforated area in the sclerotic, through which the optic nerve fibers pass out of the eye and run back to the visual centers of the brain.

Q. Give the origin of the ophthalmic artery.

Ans. The ophthalmic artery arises from the internal carotid artery at the anterior clinoid process.

Q. Name the arteries which enter the eye-ball.

Ans. The anterior ciliary arteries; the posterior ciliary arteries and the arteria centralis retinae.

Q. How does the artery supplying the retina differ from the others, as to their termination, and what is the significance of this difference?

Ans. The arteria centralis retina is an end artery, that is, its terminal endings turn back as venous capillaries and there is no collateral circulation. Therefore, if the arteria centralis retina is occluded by an embolus, sight is instantaneously lost and is seldom restored.

Q. What are the functions of the chario-capillaris?

Ans. To convey the arterial blood to the venous system. To provide nutrition to the eye. To regulate intra-ocular tension. To supply warmth to the outer layers of the retina, and in conjunction with the ciliary processes, to supply nourishment to the vitreous humor.

Q. What do you understand by afferent and efferent nerves?

Ans. An afferent nerve is one transmitting impulses from the periphery to the center. An efferent nerve is one carrying impulses from the center to the periphery.

Q. What is a mixed nerve?

Ans. A nerve made up of both afferent and efferent fibers, transmitting impulses for sensation and motion.

Q. Name the cranial nerves.

Ans. There are twelve pair of cranial nerves and they are numbered from one to twelve as follows—

(1) Olfactory, (small).
(2) Optic, (sight).
(3) Oculi, motor nerve for eye muscles.

(4) Patheticus, motor nerve for superior oblique muscles.
(5) Trigeminus, motor, taste and sensory.
(6) Abducens, motor nerve for external recti muscles.
(7) Facial, motor nerve for face muscles.
(8) Auditory, hearing; connect with internal ear.
(9) Glassopharyngeal, taste and sensation.
(10) Pneumogastric, sensation and motion.
(11) Spinal accessory, motion for muscles of the neck.
(12) Hypoglossal, controls muscles of the tongue.

Q. What nerve supplies the levator palpebra superioris?

Ans. The third or motor-oculi nerve.

Q. Describe briefly the ophthalmic nerve.

Ans. The ophthalmic nerve is the smallest of the three branches of the fifth cranial (trigemenus) nerve. Just before it enters the orbit through the sphenoidal fissure it divides into three branches, the frontal, nasal and lachrymal, which give off many smaller branches. They supply general sensation to the lachrymal gland and sac, cornea, cojunctiva, ciliary body, iris, eyelids and other nearby structures.

Q. Describe briefly the optic nerve and give its function.

Ans. The optic or second cranial nerve is noticeable for its size and furnishes no branches from its origin to its termination. It measures about two inches in length and its function is to transmit retinal impulses from within the eye to the visual centers of the brain.

Q. What nerve innervates the levator palpebra muscle and what other muscles are innervated by the same nerve?

Ans. The levator palpebra muscle is supplied by the third cranial or motor oculi nerve. The internal superior and inferior recti, inferior oblique, ciliary muscles, sphincter and Muller's muscle are also supplied by the same nerve.

Q. What nerves and veins are transmitted by the sphenoidal fissure?

Ans. The sphenoidal fissure transmits principally the third, the fourth, the three branches of the ophthalmic division of the fifth, the sixth nerve and the ophthalmic vein.

Q. What is the optic chiasm?

Ans. The crossing of the right and left optic nerve fibers at the commissure.

Q. Describe the crossing of the optic tracts.

Ans. In the optic commissure the nerve fibers of each optic tract divide, and the outer fibers of each tract are continued into the nerve of the same side, while the central fibers of each tract continue into the optic nerve of the opposite side, crossing each other. The right tract supplies the right half of each eye, while the left tract supplies the left half of each eye.

Q. How many bundles of nerve fibers are there for each eye?

Ans. About eight hundred separate bundles.

Q. How many nerve fibers are there for each eye?

Ans. There are estimated to be from five hundred thousand to a million fibers, and each one terminates in several rods or cones.

Q. What is the function of the extrinsic muscles of the eyeball?

Ans. The function of the extrinsic muscles of the eyeball is to turn the eyes so that in looking at any object the visual axes of the eyes will meet exactly at the same point on the object.

Q. What is the relative strength of the external and the internal recti muscles?

Ans. Their relative strength is one to three. The internal should have three times as much power as the external. Example: Abduction eight to twenty-four degrees of adduction would be normal.

Q. What is meant by involuntary muscles?

Ans. Involuntary muscles are those not controlled by the will.

Q. Which muscles are more subject to fatigue, voluntary or involuntary?

Ans. Voluntary muscles are more subject to fatigue.

Q. What are the anomalies of the extrinsic muscles?

Ans. Imperfections in construction, insertion or innervation, showing as some form of heterophoria or heterotropia.

Q. Aside from the ciliary muscles, what muscles are involved in hyperopia?

Ans. The internal and external recti and the sphincter muscles of the Irides.

Q. Where does the ciliary muscle arise?

Ans. The ciliary muscle arises from the point of junction of the sclerotic coat and cornea.

Q. Describe the ciliary muscles and give their function.

Ans. The ciliary muscles are part of the second tunic of the eye. They are radiating and circular. The radiating fibers of the muscles are confined to the outer portion of the ciliary body. The inner portion of the ciliary muscles consists of bundles of fibers which pursue a circular course and are hence termed the circular fibers of the ciliary muscles. They are located inside of the eyeball and control accommodation.

Q. Give the origin of the external rectus muscle.

Ans. The external rectus muscle arises from two heads, the upper one from the outer margin of the optic foramen, and its lower head from the lower margin of the sphenoidal fissure. It is the longest of the recti muscles. Its tendon is inserted into the sclerotic coat about eight millimeters from the margin of the cornea.

Q. What and where is the tendo-oculi?

Ans. The tendo-oculi is an exceedingly short and narrow muscle, situated at the inner angle of the orbit.

Q. Name the muscle that compresses the lachrymal sac, pulls the puncta against the eyeball, and gives its nerve supply.

Ans. Tensor-tarsi muscle, supplied by the seventh cranial or facial nerve.

Q. What opens the eyelid?

Ans. The eyelid is opened by the contraction of the levator palpebra superioris muscle.

Q. Name the intrinsic muscles of the eye and give their function and nerve supply.

Ans. The ciliary muscle, supplied by the third nerve, used in the act of accommodation only. The sphincter muscle is supplied by the third nerve. Its function is to close the pupil. The

dilator muscle, which dilates the pupil, is supplied by the sympathetic nerve, and the Muller's muscle assists in accommodation, and is supplied by the third nerve.

Q. Give the function of the orbicularis palpebrarum muscle, and give its nerve supply.

Ans. It closes the lids, and is supplied by the seventh or facial nerve.

Q. Give the function and nerve supply of the levator palpebrae superioris muscles?

Ans. Lifts the upper lid, and is supplied by the third or motor oculi nerve.

Q. Give function and nerve supply of the tensor-tarsi muscle.

Ans. It compresses the lachrymal sac and pulls the puncta against the eyeball. It is supplied by the seventh cranial or facial nerve.

Q. Name the extrinsic muscles of the eye and give their function and nerve supply.

Ans. Internal recti turn the eyes in, the inferior recti turn the eyes down, the superior recti turn the eyes up, and the inferior oblique rolls the eye on its optic axis. The front part of the eye moves upward and outward, while the back part moves downward and inward. The above muscles are supplied by the third cranial or motor oculi nerve. The external recti muscles turn the eyes out and are supplied by the sixth cranial or obducens nerve. The superior oblique muscle rolls the eye on its optic axis, turning the front part of the eye downward and outward, while the back part moves upward and inward. This muscle is supplied by the fourth cranial or patheticus nerve.

Q. Name the function of the corrugator-supercilü muscle and give its nerve supply.

Ans. Draws eyebrows down and inward and is supplied by the seventh facial nerve.

Q. What muscle closes the upper lid? Give nerve supply.

Ans. The lid is closed by the contraction of the orbicularis-palpebrarum muscle, and it is supplied by the seventh or facial nerve.

Chapter III
PHYSIOLOGIC OPTICS

Q. What is vision?

Ans. Vision is the faculty of seeing. It is the process by which images of objects are made upon the retina and their impressions transferred to certain brain cells.

Q. Define normal vision.

Ans. Normal vision is the standard of vision accepted as a basis in denoting the ability of the eye to recognize small objects, usually letters, on a chart at a given distance. By normal vision is meant the ability of an eye to read a line of letters on Dr. Snellen's test type from the distance at which it is numbered.

Q. Define visual acuity.

Ans. Visual acuity is the ability of an eye to see objects distinctly at a selected distance. For instance, if letters calculated for 20 feet can be seen at 20 feet, but not at a further distance, then the visual acuity expressed is 20/20, which is considered normal vision. If the patient can read the line numbered 15 feet at 20 feet it would be expressed 20/15 vision or better than normal.

Q. What is necessary to have normal visual acuity?

Ans. By visual acuity is meant the keenness or sharpness of the visual elements and depends principally on the sensibility of the retina, the eyes being normal in all other respects.

Q. What is essential to perfect binocular single vision at various distances?

Ans. For perfect binocular single vision at various distances there must be sufficient accommodation, convergence and fusion.

Q. Define direct and indirect vision.

Ans. Direct vision is the seeing by means of the fovea centralis, while indirect vision is vision within the entire field, not in direct line of fixation.

Q. Name and describe the three elements in the sense of vision.

Ans. Light sense, this being the power the retina or visual center has of receiving gradations in the intensity of illumination. Color sense is the power the eye has of distinguishing light of different wave lengths. Form sense is the power the eye posesses of perceiving the shape of objects.

Q. Where is the function of vision performed?

Ans. The function of vision takes place in the visual centers in the left frontal lobe of the brain, where the interpretation of the retinal images occurs.

Q. What is the difference between "field of vision" and "angle of vision"?

Ans. The monocular field of vision is all that one eye can see with the eye fixed in one position. Vertically, it is limited by the cheek and forehead. Laterally by the nose and temples. The binocular field of vision is all that can be seen in the same way with both eyes in use. The angle of vision is the angle subtended at the nodal point of the eye by straight lines drawn from the extremities of the object in regard.

Q. What are the conditions for normal and comfortable vision?

Ans. The necessary conditions usually are good light, correcting glasses, if needed, and reasonableness in the use of the eyes.

Q. At what distance would you test the acuteness of vision?

Ans. Acuteness of vision should be tested for both distance and near. At 6 meters distance and at ⅓ meter near.

Q. Name the important factors necessary to maintain single binocular vision at various distances.

Ans. Refraction, accommodation, convergence and fusion. Also vision in both eyes.

Q. What is the difference between acuteness of vision and an error of refraction?

Ans. The acuteness of vision is the function of the nervous apparatus of the eye, while the refraction is the function of the

dioptric system. We may define the acuteness of vision as that degree of sight which an eye possesses after any error of refraction has been corrected. The power of the glasses necessary for this correction is, therefore, the measure of the refractive error.

Q. Where are the first and second principal foci of the normal eye located?

Ans. The first principal focus is situated about 13.7 mm. in front of the cornea. The second principal focus is that point on the axis where parallel rays meet after passing through the eye, 22.8 mm. behind the cornea.

Q. What determines the visual acuity of an eye?

Ans. Primarily the transparency of the refractive media, the sensibility of the retina to light, the ability of the optic nerve to transmit these impulses and the power of the visual centers to interpret them.

Q. In what way may the iris affect the visual acuity?

Ans. If dilated, there may be exposed a part of the cornea or lens, whose refraction is sufficiently different as to blur the retinal images, or if contracted too much, it may reduce vision by shutting out the amount of light entering the eye.

Q. When binocular vision, with glasses, is not so distinct as with either eye separately, what test will show the cause of the imperfect fusion, and what may be done to correct it?

Ans. When binocular vision is not so good as monocular vision, the ocular muscles should be tested for imbalance, and, if present, ocular gymnastics given, or prisms of the correct power may be combined with the lenses.

Q. What is the advantage in correcting ametropia when visual acuity is normal?

Ans. Ametropia, with normal visual acuity, should be corrected in order that the cause of possible eye strain may be removed.

Q. What physical law is involved in the function of object seeing?

Ans. The law that a plus or positive optical system will form a real image on the retina or screen.

Q. When is a static eye in focus at a finite distance?

Ans. When the refractive condition is one of myopia.

Q. In what way are the appendages of the eye of importance to vision?

Ans. The eyelids and lashes protect the delicate anterior portion of the eyeball from foreign particles. The blood vessels supply energy, the nerves supply sensation to the eyes; also to the muscles which control the functions of accommodation and convergence, the rotations of the eyeball and the action of the iris. The extrinsic muscles rotate the eyes so that binocular single vision is maintained, and so that we may look in various directions without turning the head.

Q. In testing for visual acuity you find it not normal. Name four reasons you might suspect to be the cause of subnormal vision.

Ans. Opacities in the refractive media, amblyopia, diseased conditions and errors of refraction.

Q. What is the shape of the visual field?

Ans. The normal field of vision for each eye extends outward about 95 degrees, upward about 50 degrees, downward about 65 degrees and inward about 45 degrees.

Q. What is meant by field of vision?

Ans. All the points which can be seen directly and indirectly by the eye while in a fixed position, without moving the eye.

Q. What is meant by binocular vision?

Ans. Twofold vision. To see with both eyes at once.

Q. On what does this size of the visual angle depend?

Ans. The size and distance of the object.

Q. How is single vision maintained?

Ans. By directing the eyes so that the images of the same object fall on corresponding points of the two retinae.

Q. What causes may produce double vision?

Ans. Binocular double vision is caused by the images of the same object not falling on corresponding points of the two retinae. Imperfect fusion is another cause of binocular diplopia.

Monocular diplopia is caused by a double image of the object being formed on one retina.

Q. In what part of the brain are the visual centers located?

Ans. In the posterior part or occipital region.

Q. Name the three primary colors.

Ans. Red, green and blue. The cones are responsible for the three kinds of color sensation.

Q. How are the optic nerve impulses received and conveyed to the brain?

Ans. Optic nerve impulses are received by the retina and conveyed by means of the optic nerve fibers. Sight impressions originate in the brain.

Q. What is the effect when a ray of light falls on the retina of a normal eye?

Ans. A ray of light falling on the retina of a normal eye gives rise to sensation of light, but in order that distinct vision of any object may be gained an image of the object must be formed on the retina.

Q. What is meant by the visual purple and how is it affected by light?

Ans. The visual purple is a purplish pigment. It is bleached by light but is regenerated by the chorodial epithelium. It is found in the retinal rods only, and is also known as rhodopsin. Its principal function is to regulate the intensity of light in the retina.

Q. What and where are the anterior and posterior principal foci as applied to the dioptric system of the eye?

Ans. The anterior principal focus is a point which lies on the optic axis of the normal eye about 13.7 mm. in front of the cornea, with accommodation at rest. Light starting from this point would strike the cornea divergent and, being refracted by the dioptric media, would strike the retina as parallel rays. The posterior principal focus is that point at which parallel rays entering the eye with accommodation at rest are focused. In the emmetropic eye it is in the retina.

Q. What is the visual axis of the eye?

Ans. The visual axis of the eye is the straight line connecting the object of regard and its image on the retina passing through the nodal point.

Q. What is the function of the iris?

Ans. It automatically regulates the amount of light entering the eye. It serves to give color to the eye and prevents spherical aberration.

Q. Name the two zones of the iris.

Ans. The iris is divided into two zones, the pupillary zone and the ciliary zone.

Q. Give the diameter of the iris.

Ans. The diameter of the iris is about twelve millimeters.

Q. How many axes has the eye? Name them.

Ans. Each eye has two axes, optical and visual. The optic axis is a straight imaginary line through all centers of the eye from the center of the cornea, through the nodal points to the nasal side of the macula lutea. The visual axis is a straight line from the macula lutea through the optical center of the eye to a point on the object in regard.

Q. What are axial, corneal and lenticular errors in the eye?

Ans. Axial is when the eyes are too long on the axis to fit the principal focal distance. Corneal is when the fault is in the cornea; lenticular when it is in the lens.

Q. What difference is there in the correction of these errors?

Ans. None whatever. It is impossible to differentiate any except the corneal deformity.

Q. What protection has the eye anteriorly?

Ans. The eye is protected anteriorly by the eyebrows, eyelashes, eyelids, and by the projection of the wall of the orbit.

Q. Where are the anterior and posterior poles of the eye located?

Ans. The anterior pole is located at the center of the cornea on the outside. The posterior pole is located at the center of the back part of the eyeball on the outside.

Q. What is meant by tapetum?

Ans. Tapetum is the reflex or luminosity seen in the dark in the eyes of a cat, deer and other animals that require night vision.

Q. What function controls the relation of the two eyes?

Ans. The function that controls the relation of the two eyes is binocular single vision, which is made possible by fusion.

Q. What protection has the eyeball externally?

Ans. The eyelids are provided with cilia, which help to protect the eye from dust. Beside the protection afforded by the eyelashes, the eyebrows are also to be considered, as they prevent the sweat of the forehead from running into the eye. Also the bony structure of the skull around the eye is so arranged as to furnish a very good protection.

Q. What is the pupil?

Ans. The pupil is the aperture in the iris for the transmission of rays of light.

Q. How can the size of the pupil be changed?

Ans. It may be made larger by looking away from the light and smaller by looking toward the light. This change is produced by contraction and relaxation of the sphincter and dilator muscles of the iris. The purpose of it is to cut out excessive light entering the eye, and to allow an increase of light to enter the eye when the intensity is low. Its size ordinarily is from two to six millimeters. The size of the pupil also changes in accommodation, fear, anger, etc.

Q. On what does the size of a normal pupil depend?

Ans. On the amount of illumination that passes through it to the retina.

Q. What causes the pupil to dilate?

Ans. The pupil dilates as the result of the stimulus of light falling on the retina. The iris borders the pupil, and when its radial fibers contract and sphincter fibers relax, the pupil dilates.

Q. What is the natural pupil? An artificial pupil?

Ans. A natural pupil is one which exists at birth. An artificial pupil is one that has been made by art.

Q. What is meant by the term consensual action of the pupils?

Ans. If one eye be shaded and the other exposed to light, the pupil of the shaded eye acts in harmony with the other.

Q. What is meant by the term "hippus"?

Ans. A spontaneous, rapid and spasmodic dilation and contraction of the pupil.

Q. Explain why an eye with a small pupil has usually a higher visual acuity than one with a large pupil, provided both eyes are otherwise the same.

Ans. Most eyes with wide pupils show spherical as well as chromatic aberration, which to some extent blurs the retinal image; therefore, a somewhat lower visual acuity is present in large pupils.

Q. What is meant by binocular vision? Name two kinds.

Ans. Binocular vision is vision with both eyes at the same time. It is usually single but in case of recent squint it may be double and is termed diplopia. It can be made double by the use of a prism of sufficient strength that the ocular muscles cannot overcome.

Q. Is the eye chromatic or achromatic?

Ans. The eye is chromatic, but the pupil by contracting reduces the chromatic aberration as well as the spherical aberration.

Q. What is the result of spherical aberration?

Ans. The result of spherical aberration is to give a blurred and distorted image.

Q. What is meant by spherical aberration?

Ans. Spherical aberration is an imperfection in the image formed by a spherical lens. It is caused by the rays of light passing through the edges of the lens coming to a focus sooner than the rays passing through nearer its center, forming an imperfect focus.

Q. What is chromatic aberration?

Ans. Chromatic aberration is a separation of white light into its primary colors due to the different colors being refracted at different angles. Red the least and violet the most.

Q. Differentiate between myopia and hypometropia?

Ans. There is no difference. It is that condition of the eye in which the static refraction is too strong and parallel light focuses in front of the retina, with the muscles of accommodation in a state of rest.

Q. What is the difference between orthophoria and orthotropia?

Ans. Orthophoria is a perfect muscular balance, while orthotropia means a perfect binocular fixation.

Q. What is the nodal point of an eye? How is it determined?

Ans. An imaginary point near the posterior surface of the lens. It represents the optical center of the dioptric system of the eye and lies at the point of crossing of the optic with the visual axis.

Q. If the nodal point is 15 mm. from the retina, how large will the retinal image be of a man 5½ ft. high, standing at a distance of 65 ft. from the eye?

Ans. This is solved by the following proposition:

5½ :X::65:15=1.269 mm. answer.

5½ X 15÷65, which would be the size of the retinal image.

Q. How would you test for breadth of fusion?

Ans. By breadth of fusion is meant the measure of the power of suppressing, in the interest of single binocular vision, artificially created diplopia. Horizontal breadth of fusion is measured by prisms, with their bases in or out. Vertical breadth of fusion is measured, with prism up or down. The power of overcoming crossed diplopia (produced by prisms, base out) constitutes the positive range of fusion, and the power of overcoming homonymous diplopia (produced by prisms, base in), constitutes the negative range of fusion.

Q. What is diplopia?

Ans. Diplopia is double vision, due to the fact that the images do not fall on corresponding points in the retina and the visual axes do not meet at the object of regard.

Q. How does diplopia differ from heterophoria?

Ans. Heterophoria is a tendency toward diplopia, but is overcome by excessive action of the extrinsic muscles so that single binocular vision is maintained.

Q. With Maddox rod over the left eye, patient seated 20 ft. from light, flame is seen to the right. What kind of diplopia is present and how relieved by prisms?

Ans. This would be homonymous diplopia and is relieved by prisms, base out.

Q. With Maddox rod over the right eye, the streak is seen to the left. What phoria is indicated and how relieved by prisms?

Ans. Exophoria, and is relieved by prisms, base in.

Q. What is monocular diplopia?

Ans. Monocular diplopia is having double vision with one eye, due to marked irregularity in curvature of the cornea or of the crystalline lens; it may be produced artificially by means of a prism or lens.

Q. What is homonymous diplopia?

Ans. When each eye sees the object on its own side, the diplopia is said to be homonymous or direct.

Q. If diplopia at 20 feet is corrected by a 5° prism placed before the right eye, with the apex of the prism placed out and up 45 degrees, state the nature and amount.

Ans. Five degrees of right hyperexophoria.

Q. What kind of diplopia is present when the eyes are so directed that the images of the same object fall (a) on the nasal side of each retina, (b) on the temporal side?

Ans. (a) Homonymous diplopia. (b) Heteronymous diplopia.

Q. What is physiological diplopia?

Ans. By physiological diplopia is meant the doubling of objects nearer or farther than the point fixed. Example: If a pencil is held at an arm's length and in direct line of a light 20 feet away, and the pencil is fixed upon the light will be seen double and vice versa.

Q. Give the homonymous positions of the eyes.

Ans. Both eyes down, both eyes up, both eyes to the left, both eyes to the right, both vertical axes deviating alike, both eyes accommodating and converging.

Q. Give the heteronymous positions of the eyes.

Ans. One eye down, one eye up, one eye to the left, one eye to the right, both eyes out, one vertical axis deviating, both eyes converging without accommodating.

Q. What is the difference in meaning of antimetropia and anisometropia?

Ans. Antimetropia is that condition where one eye has an error of one kind, as myopia in one eye and hyperopia in the other. Anisometropia is a difference of refraction of the two eyes, but the same kind of refractive error, as, for instance, hyperopic 2.00 D. in one eye and hyperopic 3.00 D. in the other eye.

Q. Describe Purkinje's images.

Ans. Three images of a candle flame obtained by reflection from the cornea and the anterior and posterior surfaces of the crystalline lens. Two will be upright, while the third will be inverted and much smaller on the posterior surface of the lens, but when there is a cataract you will fail to find the inverted image.

Q. What is anisometropia, and is it always congenital?

Ans. Anisometropia means a difference of refraction in the two eyes. It may be congenital or acquired, as in aphakia. This unequal refractive condition is also termed heterometropia.

Q. What is Sturm's interval? Isometropia?

Ans. The distance or interval between the two foci in astigmatism. Isometropia is that condition in which both eyes are alike in their refraction.

Q. What is the character of the image formed in the retina?

Ans. It is a real inverted image and in a normal or emmetropic eye is situated at the focal length of the dioptric system of the eye in the retina.

Q. How far can the normal eye see letters six feet tall?

Ans. This depends to a certain extent upon the natural acuteness of vision, but if we take the five-minute angle as a standard, the distance may be found by dividing the height of the letter by the tangent of the five-minute angle.

6÷.00145=4137.9 feet.

Q. If you had to construct a test chart, what size letters would you use for 6 meters, 12 meters, 20 meters, and 60 meters?

Ans. Taking the 5-minute angle as the basis for normal vision, then we multiply the tangent of this angle (.00145) by the distance at which we wish the letter to subtend a 5-minute visual angle.

6 meters= 6000 mm. .00145× 6000= 8.7 mm., size of letter.
12 meters=12000 mm. .00145×12000=17.4 mm., size of letter.
20 meters=20000 mm. .00145×20000=29.0 mm., size of letter.
60 meters=60000 mm. .00145×60000=87.0 mm., size of letter.

Q. What is the minimum visual angle?

Ans. 1/12 of a degree or five minutes.

Accommodation

Q. Define accommodation.

Ans. Accommodation is the power of the eye to increase its refraction.

Q. Why is accommodation essential for an eye?

Ans. So as to maintain clear vision of objects within its range of vision.

Q. Name the anomalies of accommodation.

Ans. The anomalies of accommodation are presbyopia, paralysis of accommodation and spasm of accommodation.

Q. Differentiate between the range and the amplitude of accommodation?

Ans. The range is the distance of a patient's vision between the far and near point of vision. The amplitude of accommodation is the distance between the far and near point expressed in diopters.

Q. What would you recommend as the best way of getting the amplitude of accommodation?

Ans. Find the full distance correction. With this in place before the eyes, find the nearest point at which the patient can see to read fine print distinctly. This distance expressed in diopters will equal the amplitude of accommodation.

Q. When an object is nearer than twenty feet, what takes place in the normal eye in order to sustain distinct vision?

Ans. For near distances the accommodation and convergence must act in the eyes, in order that there may be perfect or distinct vision.

Q. What influence has accommodation on convergence?

Ans. Accommodation stimulates convergence. They work in harmony, when the eyes are emmetropic and orthophoric, or in equal amounts of hyperopia and exophoria, myopia and esophoria.

Q. How is accommodation produced?

Ans. Accommodation is produced by the contracting of the ciliary muscles. This pulls on the capsule of the crystalline lens by means of the suspensory ligaments, so that the lens changes the convexity of its surfaces, thus changing the refraction of the eye.

Q. What three functions must be brought into play in order to obtain distinct single binocular vision at various distances?

Ans. Accommodation, convergence and refraction. Good fusion is also necessary.

Q. Describe the commonly accepted theory of accommodation, and name the author.

Ans. The theory of accommodation commonly accepted assumes that accommodation is brought about by the contraction of the ciliary muscles, which draw the choroid forward, releasing the strain on the suspensory ligaments, which release the capsule of the lens, allowing the lens to become more convex by its own elasticity. It is known as the "Helmholtz" theory of accommodation.

Q. Explain the modus operandi of accommodation.

Ans. The modus of accommodation is a contraction of the ciliary muscles, which pull the choroid forward, releasing the tension on the suspensory ligaments. This releases the tension on the capsule of the lens and allows the lens to become more convex by its own elasticity.

Q. Describe several differences between spasm of the accommodation and myopia.

Ans. In spasm, the distance of the far point does not correspond to the amount of error as it does in myopia. The vision for distance changes, while in true myopia it remains the same. In spasm, there are asthenopic symptoms, while the eyes are used for near vision, while in myopia there is no asthenopia. In myopia, the near point is always closer to the eye than in spasm. In spasm the distant vision is better than the near, while in true myopia the near vision is better. In myopia the pupils are large, whereas in spasm the pupils are small.

Q. What is meant by accommodation?

Ans. Changing the convexity of the crystalline lens and thus adjusting the refractive power of the eye.

Q. What are the remedies used for weak accommodation?

Ans. Plus lenses relieve weak accommodation.

Q. Where is the center of accommodation situated?

Ans. It is situated beneath the floor of the aqueduct of sylvius.

Q. What is the range of accommodation of a one diopter hyperope, with a near point of sixteen inches? Give amplitude.

Ans. The range is from infinity to sixteen inches. The amplitude is three and one-half diopters.

Q. What is the difference between myopes, hypermetropes and emmetropes, as far as accommodation is concerned?

Ans. Myopes use accommodation when looking within their far point of vision. Hypermetropes accommodate for all distances, and emmetropes use accommodation when looking within infinity.

Q. How would you measure the amplitude of accommodation?

Ans. By finding the difference between the near and far point, or by correcting ametropia. Then finding the nearest point the patient reads fine print, expressed in inches. By dividing the distance into forty gives the amplitude expressed in diopters.

Q. The ciliary and internal recti muscles are supplied by the third nerve, yet the amplitude of accommodation falls off much more rapidly with age than does the amplitude of convergence. Give explanation.

Ans. Accommodation falls off with age not because of any great loss of power to the ciliary muscles, but because the crystalline lens gradually hardens with age, and thus loses its function of making its surfaces more convex, when called upon to focus near objects.

Q. Why are accommodation and convergence closely related?

Ans. Because they function together, in a fixed relation for every distance. They are also supplied by the same nerve. Another relation is one of habit.

Q. What is the difference, in meaning, between range of accommodation and amplitude of accommodation?

Ans. The two terms were originally used as meaning the same. "Range of accommodation" is the distance between the far point and the near point, when these have actual values, while amplitude of accommodation is the range of accommodation expressed in diopters. Example: A person whose near point is eight inches and far point forty inches has a range of thirty-two inches; his amplitude of accommodation is four diopters. An emmetrope who wears reading glasses and whose far point with the glasses on is sixteen inches, and his near point with the glasses on is eight inches, has a range of eight inches and an amplitude of accommodation of two and one-half diopters.

Q. Which, in your opinion, is more reasonable, the Helmholtz or Tschering theory of accommodation?

Ans. The "Helmholtz" theory of accommodation is the

one generally accepted, and seems more reasonable, although the Tschering theory is well worth consideration.

Q. What is meant by an Argyll Robertson pupil?

Ans. An Argyll Robertson pupil is one in which the reaction of light is lost, but the reaction for accommodation and convergence is preserved. It is a common symptom in locomotor ataxia.

Q. When are accommodation and convergence in harmony?

Ans. When the accommodation stimulates the proper amount of convergence.

Convergence

Q. Define convergence.

Ans. Convergence is the power of the eyes to direct the visual axis to a point nearer than infinity.

Q. What is meant by the amplitude of convergence?

Ans. Amplitude of convergence is the amount expressed in meter angles that the eyes can turn in and retain single binocular vision.

Q. Where is the far point of convergence?

Ans. The far point of convergence is the point to which the visual axes are directed when convergence is at rest.

Q. Where is the near point of convergence?

Ans. The near point of convergence is the point to which the visual axes are directed when the eyes are turned inward to their utmost degree.

Q. How is convergence measured?

Ans. Convergence is measured by meter angles. The unit of measure is the meter angle.

Q. What do you understand by meter angle?

Ans. A meter angle is the amount that each eye deviates from parallelism when looking at a point one meter away and is represented by an angle formed by a visual axis meeting the meridian line one meter away.

Q. What are the remedies used for weak convergence?

Ans. For weak convergence muscle exercise should be given or prisms may be prescribed for constant wear, base in.

Q. On what does the angle of convergence depend?

Ans. The size of the angle of convergence depends on the distance of the object looked at and on the interpupillary distance in the individual case.

Q. How many meter angles of convergence has a patient who is orthophoric and is just able to converge to a point 125 mm.?

Ans. Eight meter angles for each eye.

Q. What is meant by the term "relative convergence"?

Ans. The amount that the internal recti can act independent of accommodation.

Q. What is the amplitude of convergence when the near point of single binocular vision is at 100 mm.?

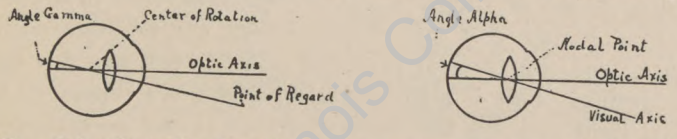
Ans. The amplitude of convergence is 10 meter angles.

Q. What is the amount of convergence necessary, expressed in prism diopters, for a subject whose interpupillary distance is 62 mm. while reading at a distance of 25 c. m.?

Ans. Reduce the pupillary distance to centimeters which gives 6.2 cm. for each meter angle. A distance of 25 cm. is equivalent to 4 meter angles, hence 4x6.2=24.8 prism diopters for the pair of eyes or 12.4 prism diopters for each eye.

Q. What is the angle gamma? Angle alpha?

Ans. Angle gamma is formed by the optic axis and a line passing from the center of rotation to the point of fixation. Angle alpha is formed by the optic and visual axis at the nodal point.



Q. Of what do the focusing arrangements of the human eye consist?

Ans. The focusing arrangements of the human eye consist essentially of three members, the ciliary muscle, the suspensory ligament and the crystalline lens.

Q. What composes the dioptric system of the eye?

Ans. The cornea, aqueous humor, crystalline lens, and vitreous humor.

Q. What are the refracting surfaces of the eye?

Ans. The anterior surface of the cornea, and the anterior and posterior surfaces of the crystalline lens.

Q. What is the dioptric apparatus of the eye?

Ans. The cornea and the crystalline lens are usually referred to as the dioptric apparatus of the eye, though some include the lens capsule, aqueous and vitreous humors.

Q. What is the dioptric power of the normal human eye? How is it calculated?

Ans. There is a difference of opinion as to the dioptric power of the eye. The cornea has a normal radius on its anterior surface of 7.8 mm., which gives 128.2 M. C. x excess index equals +42.306 D., as the power of the cornea. The crystalline lens has 100 M. C. on its anterior surface and 166.66 M. C. on its posterior surface, total 266.66 M. C. We obtain relative index by dividing 1.43 by 1.33 which equals 1.07518 relative index. Excess relative index .07518x266.166 M. C.=+20.04 as the power of the crystalline lens, which together with the cornea equals about 62 diopters of plus, which represents the curve value of the dioptric system of the eye. The separation of the cornea and lens together with the lens thickness has a space value equal to about 14.00 D. Therefore, the focal power of the eye is represented by about 48 diopters of plus which divided into the unit 1,000 mm. equals 20.8 mm. focus, which corresponds with the distance from the anterior principal point in the aqueous humor to the retina. This is also proved by the wave theory of light. Parallel light striking the cornea arrives at the crystalline lens as plus 50. D. value. The lens has a surface power of plus 20. D. minus 4.38 D. for thickness, which gives a true lens value of plus 15.62 D. Added with the value of the wave would emerge from lens as +65.62 D., and focus at about 15.2 mm. This corresponds with the distance from the nodal point to the retina.

Chapter IV
LENSES

Q. What is a lens?

Ans. A lens is a transparent refracting medium with one or both surfaces curved.

Q. What determines the focal length of a lens?

Ans. Curvature of its surfaces, density of the medium surrounding it, and density of the lens.

Q. What is the general rule for prescribing plus lenses?

Ans. Give the strongest plus that does not blur the patient's best vision for distance.

Q. What is the general rule for prescribing minus lenses?

Ans. Give the weakest minus lens that will give normal vision at 20 feet.

Q. Name five shapes of lenses.

Ans. Oval, short oval, crescent, round and leaf shape.

Q. How many kinds of spherical lenses are there? Name them.

Ans. There are two kinds of spherical lenses—convex and concave.

Q. What is the optical center of a lens?

Ans. The optical center of a lens is the point on the principal axis where the secondary axes cross. It may be inside at the surface or outside the lens, depending on the form of the lens. When it is inside it is nearest the surface of greatest convexity. Light passing through the optical center is not changed so far as direction is concerned. It is the point where refraction is supposed to begin.

Q. Name five kinds of bifocals.

Ans. Onepiece bifocal, invisible (Kryptok) bifocal, cemented bifocal, Perfection bifocal and the Franklin or split bifocal.

Q. How are lenses classified?

Ans. They are classified as diverging or minus lenses and converging or plus lenses.

Q. What is a compound lens?

Ans. A compound lens has two elements in it, a spherical and cylindrical curve, sphere and prism, or cylinder and prism.

Q. Which is harder, flint or crown glass?

Ans. Crown glass is approximately 20% harder than flint.

Q. To which surface of a toric lens of meniscus form does the term "base curve" apply?

Ans. The base curve is on the cylindrical surface of a toric lens of meniscus form.

Q. What do you understand by the term focal length of a lens?

Ans. By the focal length is meant the distance between the optical center and its principal focus. The greater the power of a lens the shorter will be the focal length. In vertex refraction this is figured from the posterior pole of the lens to its focus. From the point where the posterior refracting surface cuts the principal axis to the focus.

Q. What is the chief advantage of Ultex Onepiece Bifocals and in what form are they ground?

Ans. Their principal advantage is the entire absence of chromatic aberration. They can be supplied in exact shade ordered. They are made in two styles of segment and are ground in toric or meniscus form only.

Q. What is a Deltar lens? Mention its chief advantages?

Ans. A trade name for a Bausch & Lomb ophthalmic lens which approximates the Punktal ideal in astigmatic correction, from center to margin, but modified so as to require for its making ordinary diopter tools. This lens can be furnished by the manufacturing optician on short notice, and provides a more perfectly corrected lens than has been heretofore obtainable.

Q. What is the principal axis of a lens?

Ans. An imaginary line passing through the geometrical and optical center of the lens, perpendicular to its surface.

Q. Why should a patient look through the center of the lenses?

Ans. So as to avoid prismatic effect.

Q. Give the dioptric value of each surface of a wafer of a cement bifocal, the distance of correction being —2.00 D. sph. ⊃ +1.50 cyl. ax. 90. The addition to be +3.00 added for reading.

Ans. In this case the scale would be attached to the minus 2 D. spherical surface. One surface would be +2.00 D. and the other would be +1.00 D.

Q. If two +6 D. cylinders are placed together, one with axis at 30 and the other with axis at 120, what would be the combined power?

Ans. The two cylinders together will be equivalent to a +6.00 D. sphere.

Q. Is it possible to get "with" movement with a plus lens?

Ans. Yes, when objects are viewed through a lens held at a distance from the eye greater than its focal length.

Q. Write a regular formula for a toric lens with inner curve of minus 6 D. sph., outer curve in meridian 90+8 D. meridian 180+10.50 D.

Ans. One form of the corresponding sphero-cylinder will be +2 sph. ⊃ +2.50 cyl. ax. 90 degrees.

Q. A toric lens has a minus curvature of 6.25 D. on one side, a plus 7.50 on the 90th meridian and plus 8.25 in the 180th meridian on the other side. What is the power of the lens? Give curves of each side of a plus 2.25 D. cement segment fitted to this lens for reading.

Ans. The power of the lens expressed as a compound would be +1.25 sph. ⊃ +.75 cyl. ax. 90. Supposing the +2.25 segment to be attached to the concave side of the lens it would be —4.00 on one side and +6.25 on the other side.

Q. Are the optical principles of thick lenses the same as those of thin lenses?

Ans. Yes, but the nodal and principal points are differently located because of the thickness of the glass.

Q. In transposing the formula of a sphero-cylinder lens, what element remains the same and why?

Ans. The power of the lens is not changed in transposition. The element remaining the same is the amount of the cylinder which represents the difference between the two principal meridians and indicates the amount of astigmatism.

Q. Transpose the following into a single prescription: +2.00 sph. ⊂ —1.50 cyl. ax. 180 ⊂ —1.50 sph. ⊂ +3.00 cyl. ax. 180 ⊂ +2.00 sph. ⊂ —2.50 cyl. ax. 180 ⊂ —4.00 sph. ⊂ —1.00 cyl. ax. 90.

Ans. This result is obtained by algebraic addition. Put all the plus on one cross and all the minus powers on another, or transpose so as to have all axes alike.

	+2.00			—4.00			—2.50	
	+3.00			—2.50				
	+2.00			—1.50				
				—1.50				
	+7.00			—9.50				
		+2.00			—1.00			—2.50
		+2.00			—4.00			
					—1.50			
		+4.00			—6.50			

The effect of the combination would be —2.50 sphere. Combine the dioptric values on the vertical arms of the cross, and carry the result to the vertical arm of the third cross. Then the horizontal powers are combined and carried to the third cross. Write the Rx from the third cross.

Q. Rewrite the following prescription so that both the horizontal and the vertical prismatic correction will be divided equally between both lenses:

O.D. +1.50 sph. ⊂ + .50 cyl. ax. 90 ⊂ 1$^{\Delta}$ prism base down.
O.S. +1.75 sph. ⊂ +.75 cyl. ax. 90 ⊂ 3½$^{\Delta}$ prism base in.

Ans. The Rx will be as follows:

O.D. +1.50 sph. ⊂ +.50 cyl. ax. 90 ⊂ ½$^{\Delta}$ base down ⊂ 1¾$^{\Delta}$ base in.

O.S. +1.75 sph. ⊃ +.75 cyl. ax. 90 ⊃ ½ᴬ base up ⊃ 1¾ᴬ base in.

Q. Transpose the following sphero-cylinder to its equivalent form and explain how you do it: +2.75 sph. ⊃ —.75 cyl. ax. 180.

Ans. To transpose this we combine the two given values for the new sphere (+2.00 D.S.) and change the sign of the cylinder without altering its power, and change its axis 90 degrees. That is, if the axis is 90° or less, add 90. If it is more than 90, subtract 90, which makes +2.00 sph. ⊃ +.75 cyl. ax. 90 degrees.

Q. The axis of a cylindrical lens drilled on center was axis 120 degrees. The lens was broken out at the hole and reversed. First, right and left, then front and back. State change in the position of the axis in each case.

Ans. Reversing the cylinder right and left, the axis remains the same. Reversing from front to back, axis becomes 60 degrees.

Q. What is the difference between the shape of a lens and the form of a lens?

Ans. The shape has reference to the linear dimensions, as oval, short oval, leaf and round lenses. By form is meant the character of the surfaces, as periscopic, toric, meniscus, biconcave, etc.

Q. What kind of lenses should you prescribe in a case of glaucoma?

Ans. The optometrist should decline to prescribe glasses when glaucoma is suspected and advise patient to see an oculist at once.

Q. What is the rule for transposing sphero-cylinders?

Ans. Combine the sphere and the cylinder for the new sphere. Leave the power of the cylinder the same, but change its sign and axis.

Example: +3.00 D. sph. ⊃ —1.50 D. cyl. ax. 180.
Trans.: +1.50 D. sph. ⊃ +1.50 D. cyl. ax. 90.

Q. What is meant by changing the sign and axis of a cylinder?

Ans. Changing the sign means when it is plus change it to minus, and when it is minus change to plus. Changing the axis is done by adding 90 if it is 90 or less degrees, and subtracting 90 if it is more than 90 degrees.

Q. Is there another rule for transposing compound lenses?

Ans. Yes. When the signs are alike, both plus or both minus. Add them for the new sphere. When they are different, subtract the weaker from the greater, using the sign of the greater for the new sphere. Always change the sign of the cylinder, leaving the amount the same, and swing the axis 90 degrees.

Q. What is the difference between plus and minus spheres?

Ans. Plus spheres have a positive focus while minus spheres have a negative focus. Plus spheres form real images by refraction, while minus spheres form virtual images by reflection.

Q. Does a cylindrical lens form images? For what is a cylinder used?

Ans. Cylinders do not form images and are merely utilized to supply deficiencies and make imperfect dioptric systems spherical.

Q. What is a cylindrical lens?

Ans. A lens representing a segment of a cylinder curved in one direction and plane in the other. A surface generated about two centers of revolution.

Q. What is the axis of a cylinder?

Ans. The line at right angles to its curved surface.

Q. What is meant by the term "transposition"?

Ans. Changing the formula for a lens and thereby changing its form without altering its refractive power or its dioptric value.

Q. How many surfaces are there in a Kryptok lens and how many refractions?

Ans. There are four surfaces, two inside and two outside.

There are three refractions. One when the light enters the lens, one when the light passes through the internal junction and one when the light emerges.

Q. What is the advantage of meniscus lenses?

Ans. They have a larger and more useful field of vision with less aberration, and can be worn nearer the eye.

Q. Give some of the principal advantages of a toric lens.

Ans. The principal advantage of a toric lens is the possibility of grinding compounds with a deep concave surface towards the eye. It can be worn nearer the eye without interfering with the lashes, provides a greater and more useful field of vision, reduces spherical aberration and neutralizes the astigmatism in the eye.

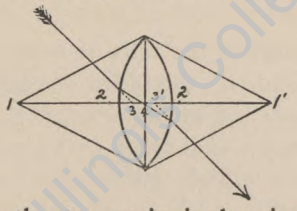
Q. In what way does a toric lens differ from a periscopic lens?

Ans. A toric lens is one that has the power of a sphere and cylinder ground on one surface. A periscopic lens is one that has plus ground on one surface and minus on the other. A lens may be toric without being periscopic. It may be periscopic without being toric, and it may be toric and periscopic.

Q. What influence do plus and minus lenses have when placed in position before the eye on the quantity of light entering the eye?

Ans. Convex lenses converge light, and therefore add to the quantity of light entering the eye. Concave lenses diverge light; therefore diminish the quantity of light entering the eye.

Q. Name the cardinal points of a lens?



Ans. They are the two principal points, two nodal points and the two principal focal points. The optical center is sometimes considered a cardinal point.

1 —Anterior principal focus.
1^1—Posterior principal focus.
2 —Anterior principal point at anterior pole.
2^1—Posterior principal point at posterior pole.
3 —Anterior nodal point.
3^1—Posterior nodal point.
4 —Optical center.

There are six in number, and, figuring the optical center, would make seven. The cordial points are important landmarks in the course of light through a spherical surface. Light, starting at the anterior principal focus, leaves the lens as parallel. Light, striking the lens as parallel, focuses at the posterior principal point. The anterior principal point is at the anterior pole of the lens. The posterior principal point is at the posterior pole of the lens. A secondary ray, aiming at the anterior nodal point, will be refracted, pass through the optical center, and after emerging will appear as though it came from the posterior nodal point. The ray will suffer lateral displacement and emerge parallel to the incident ray. The cardinal points are located on the principal axes.

Q. What is the mechanical center of a lens?

Ans. The mechanical or geometrical center of a lens is the point on its surface equidistant from opposite points on the edge of the lens. The point midway between the edges.

Q. Can a spherical prescription be transposed?

Ans. It can be transposed into a cross cylinder with axis at right angles. Example: +2.00 sph. +2.00 cyl. ax. 90 ⊃ +2.00 cyl. ax. 180 transposed.

Q. What determines the unit of lens surfaces?

Ans. This depends on the index of refraction of the glass of which the lens is made. For instance, if the index of refraction is 1.523, then .523 mm., radius of curvature, is a plano-convex or plano-concave lens, which will be the unit of curvature, producing 1 D. of power.

Q. A certain lens measures —1.25 on one side and +2.50 on the other. A bifocal scale is to be added on the minus side to

give an additional plus power of 2.25 D. What will be the power of the combination when neutralized? What will be the curves on the wafer?

Ans. The wafer must fit a —1.25 surface; hence one of its surfaces must be +1.25. As its total value is +2.25, the opposite side will have to be +1. The power of the combination when neutralized will be +3.50 D.

Q. The findings of a certain case are O.U. +1.50 sph. ⌒ +2.00 cyl. ax. 90. What curves will the lens measure show when made up toric on a +6 base curve?

Ans. The lens measure would show a +6 curve in the 90th meridian, +8 in the 180th meridian and a —4.50 curve on the inner surface.

Q. How many different ways can a sphero-cylinder lens be made up?

Ans. Sphero-cylinder lenses can be made up in seven different ways: Flat form, plus on plus, plus on minus, minus on plus and minus on minus. Toric form, plus on minus, plus on plus and minus on minus.

Q. Describe in detail each successive operation in grinding an oval lenticular lens of meniscus form.

Ans. To grind a —10 D. oval lenticular lens of meniscus form, use a rough piece of glass meniscus form about 6 mm. thick. Grind —16.00 spherical curve on the concave side 44 mm. wide. Then grind a toric concave cylinder on the same surface —6.00 on —14.00. This will make the concave spherical curve long and narrow or oval lenticular. Now grind a +6.00 D. spherical curve on the outside, which will complete the —10.00 oval lenticular lens.

Q. What is a cylindrical lens?

Ans. A lens which has power in all meridians but one, called the axis. The power varies in different meridians, the strongest meridian being at right angles to the axis.

Q. What is meant by the optical center of a lens? Where is it located?

Ans. The optical center of a lens is a point where the sec-

ondary axis crosses the principal axes, on line with the thickest part of a plus sphere or the thinnest part of a minus sphere. It may be in the lens or its surface or outside, depending on the form of the lens.

Q. How does the refractive power in a cylindrical lens vary?

Ans. A cylindrical lens possesses unequal refractive power in various meridians. In the plane of its axis no refraction occurs, while at right angles to the axis, in the plane of the principal meridian, the greatest refraction occurs. The power of a cylinder increases as the principal meridian is approached, and decreases toward the axis. A cylinder lens does not create an image.

Q. What is an achromatic lens?

Ans. The term is used to describe a lens corrected for chromatic aberration.

Q. What are generic compounds?

Ans. Lenses having spherical and cylindrical curvature of the same character that is both concave or both convex.

Q. What are contra-generic compounds?

Ans. Lenses having spherical and cylindrical curvature of opposite character, one surface concave and the other convex.

Q. What is the rule for transposing cross cylinders?

Ans. When the signs are alike, both plus or both minus, take the smaller one for the sphere, using the same sign, the difference between them for the new cylinder, using the same sign and same axis as the one used for the cylinder. Example:

Using smaller: +2.50 cyl. x 90 ⊃ +4.50 cyl. x 180.
Cylinder for sphere: +2.50 sph. ⊃ +2.00 cyl. x 180.
When using larger: +4.50 cyl. x 180 ⊃ +2.50 cyl. x 90.
Cylinder for sphere: +4.50 sph. ⊃ —2.00 cyl. x 90.
The sign of new cylinder must be changed.
—3.00 cyl. ax. 180 ⊃ +1.00 cyl. x 90.
Transposed: —3.00 sph. ⊃ +4.00 cyl. ax. 90.

Q. What is the standard, minus or plus, in the trial case? Why?

Ans. The minus lenses are the standard in the trial case

for which the opposite is made to conform in neutralization, as the nodal points are nearer the surfaces. Concave lenses do not focus light or form real images and therefore have no optical value, except as neutralizing agents.

Q. What form of spectacle lens will give the wearer the greatest field of vision and the greatest uniformity of dioptral power throughout the visual field?

Ans. The Punktal lens will produce this result.

Q. How can lenses be best examined for imperfections?

Ans. Hold the lens under a bright light and next to a piece of black velvet. Turn the lens in different directions and flaws will readily be seen.

Q. What is the advantage of the present method of marking lenses?

Ans. In the present method powers are expressed decimally. It is easier to combine decimal values than it is to combine fractional values.

Q. Is it possible to convert a generic compound prescription to a contra-generic prescription without changing its value?

Ans. Yes, by transposition.

Q. What will be the sphero-cylinder equivalent of the following cross cylinder combinations?

+1.50 cyl. x 140 ⊂ —1.75 cyl. x 50 ⊂ +.50 cyl. x 50.

Ans. —1.25 sph. ⊂ +2.75 cyl. x 140, or +1.50 sph. ⊂ —2.75 cyl. x 50.

Q. Give the focus of a spherical glass ball four inches in diameter, index 1.50.

Ans. It is a biconvex lens, each side having a radius of two inches or 5 cm. Then dioptric value of each surface $= \frac{50}{5} = 10.$

Using formula for thick lenses $P = D^1 + D^2 - (\frac{T}{N} \times D^1 \times D^2)$,

we have $10 + 10 - (\frac{1.00}{1.50} \times 10 \times 10)$, $20 - 6.66 = +13.34$, power

$$\frac{100}{13.34} = 7.4 \text{ cm., focus.}$$

Q. When is a lens periscopic?

Ans. When it is plus on one side and minus on the other on 1.25 base curve.

Q. Name three kinds of lenses, each used to correct some form of ametropia?

Ans. Plus spheres correct hypermetropia. Minus spheres correct myopia. Cylinders correct astigmatism.

Q. Name three ways of finding out whether a lens is plus or minus, cylindrical, spherical or compound?

Ans. By neutralization, or by using lens measure. It can also be calculated by tilting the lens to right and left, and moving it before the eye.

Q. An unknown lens requires +4.25 D. to neutralize the vertical meridian and —2.75 to neutralize the horizontal meridian. Write three prescriptions for this lens?

Ans. The prescriptions are as follows:
Cross cylinders: —4.25 cyl. x 180 ⊂ +2.75 cyl. x 90.
Sphero-cylinders: +2.75 sph. ⊂ —7.00 cyl. x 180.
Transposed: —4.25 sph. ⊂ +7.00 cyl. x 90.

Q. An unknown lens requires a plus 4 D. to neutralize the vertical meridian and minus 2.00 D. to neutralize the horizontal meridian. Write three prescriptions for this lens?

Ans. +2.00 D. sph. ⊂ —6.00 D. cyl. ax. 180.
—4.00 D. sph. ⊂ +6.00 D. cyl. ax. 90.
+2.00 D. cyl. ax. 90 ⊂ —4.00 D. cyl. ax. 180.

Q. Transpose the following prescriptions:

	Ans.
—.75 sph. ⊂ —.75 cyl. x 80.	—1.50 sph. ⊂ +.75 cyl. x 170.
+1.25 sph. ⊂ —3.50 cyl. x 15.	—2.25 sph. ⊂ +3.50 cyl. x 140.
+1.50 cyl. x 50.	+1.50 sph. —1.50 cyl. x 140.
+1.00 sph. ⊂ +2.25 cyl. x 75.	+3.25 sph. ⊂ —2.25 cyl. x 165.
—1.50 cyl. x 20 ⊂ +1.00 cyl. x. 110.	—1.50 sph. ⊂ +2.50 cyl. x 110.

Q. What two factors determine the dioptric power of a lens?

Ans. The curvature of its surfaces and the index of refraction of the lens.

Q. Describe fully how you would neutralize a contrageneric compound Kryptok lens, with the trial case lenses?

Ans. This lens would be neutralized the same as any compound bifocal. Would first neutralize the sphere in the distance portion of the lens by using a sphere from the trial case of opposite kind and proper strength. Then with the sphere held in position would use cylinder from the trial case, with proper strength to neutralize the cylinder also of opposite kind. Then with the neutralizing sphere and cylinder in position would neutralize the reading addition by using a sphere from the trial case of opposite kind and proper strength.

Q. What is the essential difference between crown and flint glass?

Ans. The flint glass contains salts of lead, which makes it soft, and it has a higher refractive index than the crown glass.

Q. Why should plus cylinders be used in compound lenses when cement bifocals are wanted?

Ans. The cylinder should be ground on the outside, leaving the side to be placed toward the eye spherical. Scales cannot be placed on the cylindrical surface of the lenses in bifocal form.

Q. What is the difference in lenses as indicated by the factory terms meniscus and toric?

Ans. Meniscus means that it is more periscopic than is necessary to produce the same refracting power. A toric lens has a spherical and cylindrical curve on the same side. The other surface may be flat or spherical. The unequal curve, produced by the cylinder, gives the lens its toric effect.

Q. What are the three principal base curves used in meniscus lenses?

Ans. Three, six, and nine base curves are the principal curves used. The nine B.C. is considered a deep meniscus.

Q. How may the true value of a thick lens be determined?

Ans. Use the formula $D^1 + D^2 - (\frac{T}{N} \times D^1 \times D^2)$.

D^1 = Dioptric value of one surface.
D^2 = Dioptric value of other surface.
T = The thickness expressed in fractional parts of a meter.
N = Index of refraction of the glass.

Q. How many kinds of lenses are there?

Ans. Two, spherical and cylindrical.

Q. What effect does a cylindrical lens have on rays of light?

Ans. Light passing through the plane of its axis is not refracted; its speed is retarded only; but when the light passes through in a plane opposite or perpendicular to the axis of a cylinder, the rays are rendered convergent or divergent, according as the cylinder is convex or concave.

Q. What is an orthoscopic lens?

Ans. An orthoscopic lens has two elements of refractive power, combined with a prism, intended to put accommodation and convergence in harmony.

Q. What is the dioptric difference between a minus 2.00 D. sph. and a plus 2.00 D. sph.?

Ans. Four diopters.

Q. What is the dioptric curve of a 10 centimeter radius?

Ans. A 10 centimeter radius equals a 10 meter curve.

Q. What would be the center and edge thickness of a plus 1.00 D. spherical lens, 40 mm. in diameter?

Ans. Square the radius which equals half of the diameter and point off three places. This gives the center thickness for a +1.00 D. lens without any edge thickness. Then add the desired edge thickness to the center thickness. Example: 40 mm. = 20 mm. radius $20 \times 20 = .400$ mm. center thickness for a 1.00 D. lens. Then multiply by the number of diopters of power wanted and add desired edge thickness.

Q. How would you calculate the center and edge thickness of a minus 1.00 D. lens, 40 mm. in diameter?

Ans. Square the radius and point off three places, which equals edge thickness without any center thickness. Multiply by the number of diopters in the lens and add the desired center thickness. Example: $20\times20=.400$ mm. edge thickness without any center thickness. Therefore, if a minus 3 D. lens is wanted with a center thickness of .8 mm., the edge thickness would equal $.400\times3+.8=2$ mm. edge thickness.

Q. Are high-powered meniscus lenses always satisfactory? Why?

Ans. Meniscus lenses of high power are not always satisfactory on account of their strong curves causing distortion. In high powers, Punktal or Kartal lenses should be prescribed, or bi-convex or bi-concave in lenticular form.

Q. Why do we sometimes prescribe plus lenses which somewhat blur distant vision?

Ans. For the purpose of relaxing spasm of accommodation in latent hyperopes.

Q. Give reason why strong lenses of like powers with opposite signs fail to neutralize each other.

Ans. They fail to neutralize because their optical centers do not coincide when held together.

Q. Do you prescribe the weakest or strongest plus lens which gives the best vision at 20 feet.

Ans. The rule is to prescribe the strongest plus lens that does not blur vision at 20 feet. Under certain conditions, however, more plus should be prescribed.

Q. What do you understand by the term neutralize?

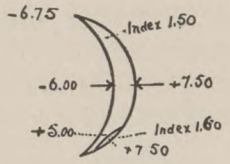
Ans. A term used in optometry to designate the process of finding the power of an unknown lens or prism, by employing lenses or prisms of known power. To neutralize means to render inactive. Optically we employ convex and concave power of equal strength, and thereby destroy the effect of both.

Q. How would you determine the foci of a fused bifocal lens?

Ans. Neutralize the upper and lower portion of the lens with trial case lenses, and divide the power of each lens into 40, which will equal the foci.

Kryptok Lenses.

Q. What would be the curves on a Kryptok lens made toric on a —6 B. C., using the following Rx.: +1.50 sph. ⌒ —.75 cyl. ax. 180 with +2.50 added for reading, index of glass 1.50 and 1.60. Show by diagram.



Ans.

1.60 Index of lower.

1.50 Index of upper.

.10).50(5 the curve necessary to gain one diopter. To gain 2.50 D. would require 5×2.50=+12.50 curve. We already have +7.50 D. curve on the outside of scale, therefore the inside scale curve must be +12.50 minus +7.50 equals +5.00 D. curve.

Q. Describe a fused bifocal lens. Name the different constituents and state advantages and disadvantages of this lens.

Ans. A lens made of two kinds of glass, and fused together by special heating process. The reading segment is made of glass which has a greater refractive index than the distance portion.

The constituents are crown glass and flint glass.

The advantages of this lens are that it gives two foci, distance and near, yet the segment is practically invisible. Dirt cannot collect around the edges of the segment; there is no discoloring and the scale can not come off. It is ground from a

blank as a solid lens. The disadvantages of this lens are that the flint glass in the segment, having greater index than crown, causes chromatic aberration which may be troublesome to the wearer. This is especially true where the addition for reading is high. Commercially the disadvantage of this lens is the high cost to the wearer, when breakage occurs frequently.

Q. Why should the optical centers of glasses, for close work, be three to four millimeters nearer together than the optical centers in glasses for distant vision?

Ans. For near work the eyes turn inward, in convergence and the interpupillary distance is decreased.

Q. Taking a +1.25 lens from the trial case, what other lens must be added to it to produce a positive focus of two meters?

Ans. A lens with a principal focus of two meters is a +.50 D. lens. To change from +1.25 to +.50 we must add to the +1.25 lens a —.75 D. lens.

Q. If the glass used in a fused bifocal lens has indices 1.50 and 1.65 what would be the countersunk curve that would produce +2.00 of added power? What curve would have to be ground on the other surface of the disc to give a total add of +3.00 D.?

Ans. 1.65—1.50=.15.

$\frac{.50}{.15}$=3.33, the countersunk curve which would add +1.00. Then to obtain +2.00 the curve would be 2x3.33=6.66 D. The tool to be used would be 6.66 D. To make the total add +3.00, the power on the other surface of the disc must be +1.00. Since the tools are made for crown glass. Then to find the tool to give +1.00 D. on 1.65 glass we use the formula, .50:.65::x1.00, then .65x=.50, then x=.76. Tool used on outer surface of segment would be .76 D.

Q. What is the difference between the inch system and the metric system of numbering ophthalmic lenses? Tell how a lens of one system may be expressed in the other system.

Ans. In the inch system the power of lenses is expressed by their principal foci in inches. In the metric system the power

of the lenses is expressed in meters, or decimal fractions of a meter. To change from one system to the other we divide into our unit. For instance, a 4.00 D. lens equals a 10-inch lens and vice versa.

Q. What is the present system of numbering lenses?

Ans. The Dioptric system. The standard of measurement is a lens whose focal length is one meter, which is called a one dioptric lens. This lens would correspond to a 40 inch lens, in the old English system.

Q. What is meant by dioptric distance?

Ans. Any distance, expressed in diopters.

Q. What is the Dioptric curve of an 8 inch Radius?

Ans. An 8 inch radius equals five meter curves.

Q. What are the dioptric curves necessary to make a toric Kryptok lens +1.00 sph. ⌒ —.75 cyl. ax. 180, add +3.00, indices 1.50 and 1.62?

Ans. In order to grind the toric surface on the inside, a —6.00 base curve may be used. This side must then be —6.00 at 180 and —6.75 at 90. On this inside surface we get the effect of —6.00 sph. ⌒—.75 cyl. ax. 180. Since the Rx. calls for +1.00 sph. ⌒—.75 cyl. ax. 180, the outer surface must be ground +7.00 sph. This is the segment side. We find the tool to be used on the countersunk curve in the following way: 1.62—1.50=.12, .50÷.12=4.16, tool curve to add +1.00. To add +3.00 the curve would be 3x4.16=12.50, but we cannot gain the total add in the countersunk curve since a convex curve must be ground on the outside. The tool used for outer surface being 7.00, then by subtracting this from 12.50 we get 5.50 the tool to be used for the counter sunk curve.

Q. A regular +4.00 tool is used to grind each of four lenses:

(a) Index 1.52
(b) Index 1.60
(c) Index 1.62
(d) Index 1.66

What is the focus of each?

Ans. We will assume that the tool is made for crown

glass of index 1.52. Power of first lens will be 4.00 D., and its focus 10 inches. Divide the dioptric curve of the tool by the difference of index of crown glass and we get the metric curve. 4.00÷.52=7.69 M. C. Then M. C. times difference of index equals dioptric power.

Power of second lens (Index 1.60=7.69x.60=4.61 D. 40÷ 4.61=8.67 in. focus.

Power of third lens (Index 1.62)=7.69x.62=4.76 D. 40÷ 4.76=8.4 in. focus.

Power of fourth lens (Index 1.66)=7.69x.66=5.07 D. 40÷ 5.07=7.889 in. focus.

Q. What is meant by first grade lenses?

Ans. A first grade lens is one free from pit marks, and is accurately centered.

Q. What is meant by accurately centered?

Ans. Being accurately centered means that the optical center and the geometrical center coincide.

Q. What is a secondary axis of a lens?

Ans. Any line drawn through the optical center not perpendicular to both surfaces.

Q. How are cylinders measured?

Ans. By neutralizing by focal length or by lens measure.

Q. How can the strength of a plus spherical lens be estimated without trial lenses or a lens measure?

Ans. By finding its principal focal length. This distance divided into 40 gives the dioptric value of the lens.

Q. What is a meridian?

Ans. A meridian of a sphere is a line drawn around its circumference so as to divide the surface into two equal hemispheres. A meridian of a circle is a straight line drawn from circumference to circumference and passing through the center.

Punktal Lenses

Q. What is a Punktal Lens?

Ans. A Punktal Lens is an ophthalmic lens ground to

curves which have been mathematically determined as most suitable, taking into consideration the fact that all image forming rays must pass through a small area at the center of rotation of the eye. Each separate power whether an ordinary sphere or a compound is ground to the curves best suited to it. The curves vary continuously from power to power and no base curve can be employed such as is used in ordinary trial lenses.

Q. What is the advantage of these Punktal Lenses?

A. Punktal lenses enable an eye to look through the center of the lens or any other portion within a total angle of 60° without encountering astigmatism in oblique pencils, thus enabling a patient to rotate the eyes within the angle mentioned above, observing clear and distinct vision from the center of the lens to its very margin.

Q. What is the highest power in which Punktal Lenses can be obtained?

Ans. In the plus powers Punktal Lenses are made up to 7.50 diopters; in the minus same reach up to 20 diopters.

Q. Are lenses made corrected for astigmatism in oblique pencils of high plus power?

Ans. Lenses made specially for this purpose are known under the name of Katral Lenses. These lenses, however, are of a complex construction, having one or the other surface deformed (aspheric) as the case may be, in order to eliminate astigmatism in oblique pencils.

Q. Who is the originator of Punktal and Katral Lenses?

Ans. Punktal and Katral Lenses originated on the suggestion of Prof. Gullstrand, who demanded ophthalmic lenses corrected within a total angle of 60° so that all rays passing through the ophthalmic lenses and center of rotation of the eye focus precisely on the fovia centralis. The actual curves required for such lenses were calculated by Prof. Morritz Von Rohr, a member of the scientific staff of Carl Zeiss, Jena.

Q. By whom are Punktal Lenses manufactured in the United States?

A. The Bausch & Lomb Optical Company, Rochester, N.

Y., are the only manufacturers of Punktal Lenses in the United States; being leading lens manufacturers of the world, the Carl Zeiss, Jena, Optical Company placed the entire production of Punktal lenses for the United States in their hands.

Q. What are the principal advantages of Punktal Lenses over other forms of lenses?

Ans. A Punktal lens furnishes a uniform correction from the center of the lens to the margin, free from astigmatism in oblique pencils which cannot be claimed for ordinary meniscus or toric lenses, thus proving the Punktal lens to be a precision lens of the highest order.

Q. How is such accuracy obtainable?

Ans. Carefully constructed machines marked by expert lens grinders and using the best selected material under strict control of a Scientific Bureau are the requirements essential for the production of these high class lenses.

Q. How is the power of Punktal Lenses designated?

Ans. The power of Punktal Lenses is designated in Vertex Refraction (Dv) which means that their focal length is determined from the vertex of the surface of the lens nearest to the eye to the back focal point, instead of from the principal point to the focal point as is the case in the ordinary dioptric system. From this it follows that Punktal Lenses can be prescribed according to the findings of ordinary flat trial case lenses, giving number for number and thus simplifying refraction work considerably, while with the ordinary meniscus and toric lenses, particularly with the higher powers, allowance has to be made for the difference in the positions of the principal points of trial case lenses and of meniscus or toric forms.

Radius of Curvature.

Q. How would you find the radius of curvature expressed in centimeters when the index of the glass and the power of lens is known?

Ans. Excess or difference of index divided by the power equals radius in centimeters. Principal focus expressed in inches

times excess index equals the radius in inches. Also 40 divided by the meter curve gives radius in inches.

Q. What is the usual dioptric curvature of the posterior side of a periscopic convex lens?

Ans. The usual curve on the posterior surface is minus 1.25 D.

Q. What is the radius of curvature of a concave mirror that focuses parallel light at 33 inches?

Ans. Its radius is 66 inches.

Q. What relation exists between the index of refraction of a lens and its surface curvature?

Ans. The higher the refractive index of the glass the longer the radii of curvature of the lens required to produce a given dioptric power.

Q. What is the rule for figuring the radius of curvature of lens surface, the index of refraction and the focal power of the lens being given?

Ans. Power divided by difference of index equals the meter curve. The unit 40 divided by the meter curve equals the radius, or focus times difference of index equals radius.

Q. What curvature must be given to the two surfaces of a wafer to add +2.50 D. for reading, the distance correction being +1.50 cyl. ax. 90, and the lens to be made on a plus 6.00 D. base curve?

Ans. The back spherical curve of the lens will be —6.00 D. This fixes the one surface of the segment as +6.00 D. As the total strength of the segment is to be +2.50 D., the other side must be —3.50 D.

Q. As a rule which one of the two principal meridians of the eye has the greater curvature?

Ans. The greater curvature—that is, the higher dioptric power—is usually vertical or nearly so.

Q. A certain double convex lens is made of crown glass, having a refractive index of 1.50. One surface has a surface curve with a radius of 12 inches and the other side a radius of 24 inches. What will be its principal focus?

Ans. Rule: 40 ÷ by radius equals the M. C.
12″ R. = 3⅓ M.C., 24″ R. = 1⅔ M.C.; total, 5 M.C.
Meter curve times excess index equals power.
Thus: 5 M.C. x .50, excess index, equals +2.50 D., which would focus parallel rays of light at 16 inches or 40 C.M.

Q. Find the radius of curvature of a double convex lens, with power of +20.00 D. index of refraction 1.523—.

Ans. With index of refraction 1.523, a radius of curvature of 523 mm. will produce 1.00 D. To get the radius of curvature of the biconvex lens divide 10 into 523, which equals 52.3 mm. Hence the radius of curvature of each of the equally curved surfaces will be 52.3 mm.

Q. What is the relation between the radius and focal length of a biconvex (double convex) lens made of crown glass?

Ans. The focal length is practically equal to the radius of curvature. In a plano-convex lens the focal length is twice the radius, or the diameter of curvature.

Q. If a double concave lens could be made of air and immersed in water, what would be the nature of its refraction and action on parallel rays of light, if the radius of each side is 10 cm.?

Ans. Since water is denser than air, or has a higher refractive index, and we would have convex curves on the water, the refraction would be plus. Index of water is 1.33. The dioptric value of each surface equals 33/10=3.3, power of the lens equals 2×3.3=+6.6 D. Hence it would focus parallel rays at 100/6.6= 15.15 cm.

Q. What is the dioptric power of a plano-convex lens whose radius of curvature is 10 inches, the index of the glass being 1.50?

Ans. Forty divided by the radius equals the meter curve. 40÷10=4 meter curves. Meter curves times difference of index equals the power .50×4=2.00 D. lens.

Q. What is the focus of a plano-convex lens? Index of Ref. 1.50, radius of curvature 20 cm.

Ans. The principal focus of this lens would be 40 cm., or 16 inches.

Q. If a double concave lens could be made of air with its radius of curvature 40 inches for each side, what would be the nature of its refraction if it were immersed in water, and what would be its action on parallel rays of light?

Ans. Its refraction would be plus in the water, as water has a greater index than air, and the curves on the water would be convex.

Relative index equals 1.33/1.00=1.33. Then metric curve times (N—1)=D.

R. 40 inches = 1 M.C. Then power of each surface is 1×.33=+.33 D.

Adding the two surfaces together, we have +.66 D. for power of lens in water. It would converge parallel rays, bringing them to a focus at 100/.66=151.5 cm.

Q. What is the radius of curvature of a plus 2.00 D. lens made of crown glass?

Ans. This question is not complete, as it does not state index of glass or form of lens. Assuming the index to be 1.523 and the lens plano-convex, the radius would be 261.5 mm. If bi-convex, the radius would be 523 mm. for each surface.

Q. The radius of the anterior surface of the cornea is 7.8 mm. with an index of 1.33. What would be its principal focal distance in a substance with an index of 1.33?

Ans. Radius divided into the unit reduced to mm. gives 128.2 M.C. Multiplied by the excess index 128.2×.33 equals +42.30 power, divided into 1000=23.64 mm., as the principal focal distance.

Q. What is the focus of a lens whose radius of curvature is 8 inches and index of refraction is 1.50?

Ans. The principal focus of this lens will be 16 inches. 40/8 R. = M.C. 5 M.C. × .50 excess index = 2.50 D. ÷ into 40=16 inches.

Q. A plus lens has a focus of 30 cm. The index of the glass

used is 1.60; one surface is convex with a radius of 12 cm. What is the nature and power of the other surface? Show calculation.

Ans. Power of lens=100÷30=3⅓ D.

Power of convex side 12 cm.=60÷12=5.00 D. Since power of lens = +3⅓ D. and one surface is +5.00 D., then the other surface must be +3⅓—(+5.00)=—1⅔ D.

Q. A certain lens has a surface power of +6.25 D. on one side and on the other —1.25 D. What curvature must a cement segment have to make the reading portion +6.50 D. when the index of refraction is the same in both parts of the lens?

Ans. With a plus 6.25 curve on one side and a —1.25 on the other it would make the lens a +5.00 D. sph. In order to make the reading portion +6.50 D. the cement segment must have a power of plus 1.50 D.; therefore, the curve facing the lens must be +1.25 and the other +.25 D.

Q. If a concave mirror has its center of curvature at 40 inches and a candle flame is placed at 20 inches from the mirror, where would the focus be?

Ans. There would be none, since the object is situated at the principal focus of the mirror, and the rays would be reflected parallel.

Q. If light traveling from a point has a radius of curvature of 200 mm. and passes through a plus 9.00 D. lens, then travels 500 mm. further and enters a plus 6.00 D. lens, where will it then focus?

Ans. The light in this case would require a +5.00 D. to render it parallel, for it is 200 mm. away from its surface. But the lens is a +9.00 D.; therefore, the wave would emerge as a plus 4.00 D. value, and focus at 10 inches. Now the distance between lenses is 500 mm., 50 cm. or 20 inches, so the wave would arrive at the plus 6.00 D. lens as a minus 4.00 D. wave, and emerge as plus 2.00 D. value and focus at 50 cm., 500 mm., or 20 inches.

Q. Mention some of the properties that you consider most essential in glass to be used in ophthalmic lenses.

Ans. The glass should be hard, capable of taking a high polish, pure in color, free from bubbles, and of a uniform index throughout.

Q. What is meant by focus as relating to a lens?

Ans. The focus of a lens is that point where light coming through the lens meets at a point or seems to come from a point.

Q. An unknown lens requires a +3.00 D. to neutralize the vertical meridian and a minus 2.75 to neutralize the horizontal meridian. Write three prescriptions for this compound.

Ans. —3.00 sph. ⊂ +5.75 cyl. ax. 90.
+2.75 sph. ⊂ —5.75 cyl. ax. 180.
—3.00 cyl. ax. 180 ⊂ +2.75 cyl. ax. 90.

Q. What is a plano?

Ans. A transparent substance with two plane surfaces parallel. It is a neutral lens. Its principal focus is at infinity, and its optical value is zero.

Q. What is meant by vertex refraction?

Ans. The dioptric value of a lens is computed on its focal length, as measured from the posterior surface of the lens. In ophthalmic lenses this would be measured from the posterior surface or from the side of the lens, which is to be placed next to the eye.

Q. How may one readily determine the character of a lens, whether positive or negative?

Ans. By holding the lens near the eye and viewing objects through it, repeatedly moving the lens slightly upward and downward or sidewise, observing the apparent movements of the objects looked at. If the objects appear to move in the opposite direction, the lens is positive. If they appear to move in the same direction the lens is negative.

Q. A compound lens has a power of +2.50 sph. ⊂ —3.00 cyl. ax. 35°. Which side would you place next to the eye? If the lens is reversed with wrong side towards the eye, what would be the difference, if any, in the position of the axis of the cylinder.

Ans. The rule is to place the least convex or the most

concave surface towards the eye. So the —3.00 D. cyl. would be placed next to the eye in this case. The axis would be 145 degrees, if the lens is reversed, a difference of 110 degrees.

Q. Describe how bifocal lenses should be adjusted and the position which the reading portion should occupy.

Ans. The scale should be placed inward from one to two mm. according to the P.D. of the patient, and the upper part of the scale should be on line with the upper margin of the lower lid. The upper part of the lens should be tilted slightly outward.

Q. Does decentering a spherical lens make it a sphero-prism or to make a sphero-prism must a prism be ground into the lens?

Ans. A decentered lens is not a sphero-prism, but is known as a decentered lens. Although it produces prismatic effect while looking through the geometrical center, lenses are often decentered where large lenses are desired and when the patient has a narrow P.D., to avoid prismatic effect. They would therefore not be classified as sphero-prisms. A sphero-prism has the elements of a prism incorporated within the lens.

Q. What is the advantage and disadvantage of a lenticular lens?

Ans. The advantage of a lenticular is its light weight and appearance. Its disadvantage is a reduced field of vision and high cost.

Q. Which has the most dispersive power, crown or flint glass?

Ans. Flint has the most dispersive power, due to its higher refractive index.

Q. What is a decentered lens?

Ans. A lens with its optical center to one side, or above or below the geometrical center.

Q. What do you understand by the term, the surface power of a lens?

Ans. The surface power is the dioptric curve value, as indicated by the lens measure, when the lens measure is gauged for the index of the glass.

Q. What is meant by Dioptric value of a lens?
Ans. The strength of the lens expressed in dioptres.

Colored Lenses

Q. Name six kinds of colored lenses. Give their respective value and absorption of the spectrum.

Ans. First let us bring to mind the spectrum common. Colors as follows: Red, yellow, green, blue and violet, while on the spectrums foremost, and we have heat rays or the invisible rays, while beyond violet we have ultra-violet and others, as the X-rays.

We shall take in comparison the six prominent color lenses —names, Noviol, Crookes, Fieuzal, amethyst, smoke and blue, each being represented by several shades.

To bring out in detail would call for many chapters. We shall restrain ourselves to simple and necessary facts regarding the different shades and their absorbing qualities in percentage.

"A" shade Crookes 10% red, 50% yellow, 40% green, then crosses blue and violet at about 20%.

"B" shade Crookes 30% red, 70% yellow, 60% green, then crosses blue and violet at about 45%.

Fieuzal "A" shade, while it absorbs 20% red, crosses the entire spectrum yellow, green and blue at 10%, then rising to 30% absorption of violet and ultra-violet.

Fieuzal "B" shade, beginning at 40% absorption of red, drops to 10% for yellow and green, while at blue it is again to the height of 40%, with violet at 60% absorption.

Noviol "A" shade, while it absorbs not more than 5% completely across the spectrum to violet and ultra-violet, it absorbs 70% violet, with ultra-violet practically absorbed.

Noviol "B" shade, as "A" shade, absorbs not more than 10% of all colors until approaching violet and ultra-violet, violet being absorbed at 90%, with ultra-violet entirely absorbed.

Noviol "C" shade, like the other two shades, absorbs not more than 10% red, yellow and green, then climbs quickly to the

height of 70% absorption of blue, while violet and ultra-violet are entirely absorbed.

Amethyst "A" shade as an even rate of 20% absorption from red and violet, then having a tendency to lose its value, with violet being at 10% absorption.

Amethyst "B" shade as 30% absorption value with red and yellow, while with green it reaches its greatest point of value, being 50%, then gradually declines through blue and violet to 30% absorption value.

Smoke shades, unlike the previous colors, absorb almost evenly across the entire spectrum at their respective quality with the exception of "C" shade.

"A" shade smoke with absorbing value at an average of 10% from red to blue has a tendency to lose value with violet.

"B" shade smoke with absorbing value at an average of 20% through the entire spectrum.

"C" shade absorbing value 50% at red, yellow, green and blue, with 70% at violet and ultra-violet.

"D" shade smoke acts evenly completely across the spectrum at an average of 80%.

Blue lenses:

"A" shade blue lenses reaches its highest mark at red, being 40% absorption, and gradually losing value completely across the spectrum to violet, where its entire value of absorption is lost.

"B" shade blue lenses, like "A" shade, reaches its highest value at 60% red absorption, gradually losing value to violet where same is of 5% absorption quality.

"C" shade blue lenses, unlike the others quoted above, absorbs 50% red, while its greatest height of absorption is through yellow, with value of 65% absorption; then gradually losing value as the other shades until it reaches violet, where its value of absorption is 10%.

"D" shade blue lenses has a value of 20% at red, 35% at yellow, 80% at green, 50% at blue, while violet reaches its highest rate of absorption, same being 20%.

With all the evidence to hand one can judge easily what color lenses shall be given their patient for their respective uses. This, however, brings into question the amber-colored lenses which are commonly used and must be given space in this volume.

"A" shade amber at red has an absorbing value of 20%, with the same value at yellow and green, but at blue rises to the mark of 40%, and with a still higher increase at violet of 50%.

"B" shade amber, like "A" shade, has the same quality at red, yellow and green—namely, absorption of 20%—while at blue it reaches to the height of 50% and at violet 70%.

With the subject on these items closed, would recommend after due consideration the "O" shade Noviol and "A" Crookes lenses for constant use, while "C" shade Noviol stands out most prominent for outdoor uses, such as golf, tennis, boating, hunting, etc. The "B" shade of blue is beneficial in cataract cases if prescribed in time, as it tends to absorb the cataract. The Crookes B1 and B2 are beneficial in cases of hay fever, as they often afford relief while glasses are worn. The ratios as given on the respective colors and their own respective shades are average findings, which will prove a great help to the refractionist.

Color of Glass.	Origin.	Year Invented.
Green	England	1561
Blue	England	1672
Smoke	England	1767
Amber	England	1832
Fieuzal	France	1880
Amethyst	Philadelphia	1885
Helour	Switzerland	1905
Euphos	Germany	1907
Noviol	Chicago	1914
Crookes	England	1915

Q. What are the four essentials of a perfect dioptric system?

Ans. Transparency, optical density, symmetry and adjustability.

Prisms

Q. What is the difference between the diopter and the prism diopter?

Ans. The diopter is the system of measuring lenses, and is based upon that lens which will focus parallel rays of light at one meter or 40 inches from its nodal point, vertex from its posterior surface, the same being a 1.00 D. lens. The prism diopter is a method for measuring and notating prisms, and is represented by a prism which will deflect rays of light one centimeter in one meter's distance. This is called the 1.00 D. prism.

Q. What is meant by prism?

Ans. A prism is a transparent medium with two plane surfaces not parallel.

Q. What is the effect of light passing through a prism?

Ans. The light is refracted toward the base of the prism, the refraction varying with the color of light, acting least on the red and most on the violet.

Q. Upon what does the deviating power of a prism depend?

Ans. It depends upon its angles and its index of refraction.

Q. What is a centrad?

Ans. A centrad is a unit of prism power which will produce a deviation of light equal to the one-hundredth part of the arc of the radian, and causes deflection of light .57295°, or approximately half a degree.

Q. What are gymnastic prisms?

Ans. Prisms placed before the eyes for the purpose of strengthening the muscles of the eyes by exercise.

Q. Describe the double prism.

Ans. An opaque disc with a slit-like opening. Over this slit there are two prisms with their bases together. Used for testing muscular imbalances.

Q. How should a prism be placed to relieve a weak muscle?

Ans. A prism prescribed to relieve a weak muscle has its base towards or over the weak muscle. Thus, a prism base in affords relief to the internal recti, base out to the external recti.

Q. What is a double rotary prism?

Ans. A rotary prism consists of two prisms mounted so that they are in opposition and neutralize each other when in their primary position. By means of a mechanical arrangement they can be rotated so that the two bases approach each other. If the primary position is vertical both bases can be made to rotate toward the horizontal, to the right or left, thus producing a gradual increase horizontally, while the vertical remains neutral. When both apex planes are horizontal the maximum power results, and this is equal to the sum of 30 prism diopters or 60 prism diopters for the two eyes. The amount of prism effect is indicated by a pointer and a scale on the mount.

Q. For what purpose and how is a rotary prism used?

Ans. The rotary prism is used for measuring the power of the extrinsic muscles of the eye. It is used in giving ocular gymnastics, developing the weak muscles, and measures the degree of muscular imbalances.

Q. How is the power of the abductors measured?

Ans. By prisms, base in. The highest power of prism that will permit single binocular vision is the measure of the abduction.

Q. What is a lens called if it has a prism in it?

Ans. It is called a sphero-prism, or if a compound with a prism, a sphero-cylinder-prism. It is also called a composite lens.

Q. Is a prism a lens? Give reason for answer.

Ans. No; because it has no curved surfaces and does not focus light. (Optically a prism is considered a lens.)

Q. How many degrees of deviation would a prism of 20 degrees angle produce on light if the index of refraction of the glass is 1.50?

Ans. Ten degrees.

Q. In looking through a prism at an object, why is there an apparent displacement towards the apex of the prism?

Ans. Because the rays are bent towards the base of the prism; therefore, we project the image toward the apex on

account of the direction the light is traveling when it enters our eye.

Q. How would you find the strength of the prism in a decentered lens? How would you find the amount in millimeters to decenter a lens for prismatic effect? How would you find the power of a decentered lens?

Ans. The unknown quantity may be found by the following proportion:

Key: Par-Mee-Lee-Ten.

Prism.	Mm.	Lens.	Ten.
x	6	2.50	10) 6×2.50=15÷10=1.5$^{\Delta}$ Ans.
1.5	x	2.50	10) 1.5×10=15÷2.50=6 mm. Ans.
1.5	6	x	10) 1.5×10=15÷6=2.50 Power Ans.

Q. What decentration would be required in order to correct four degrees of right hyperphoria, dividing the correction equally between two eyes.

O.D. +4.00 sph. ⌒ —1.00×180, O.S. +1.00 D. sph. ⌒ —5.00 D. cyl. ax. 180.

Ans. The right lens must be decentered 6⅔ mm. down and the left lens 5 mm. down, as the lens is minus in the vertical meridian.

Q. If a pair of +6.00 D. spheres are each decentered 5 mm. inward, what would be the prismatic effect?

Ans. The prismatic effect in each lens is 3.00$^{\Delta}$, making the total for the two lenses 6.00$^{\Delta}$, base in.

Q. How many meter angles would an emmetrope who is orthophoric have to converge to read at 13⅓ inches, while looking through a pair of +3.00 D. spheres, decentered in, 20 millimeters?

Ans. One meter angle.

Q. What is the amount of decentration necessary to produce 2△, base in, on a pair of plus 4.00 D. cylinders, axis 90 degrees?

Ans. The maximum power of these cylinders lies in the 180th meridian. As we have 8.00 D., in all, to produce 2△, the

total decentration required will be 2.5 mm., or for each lens 1¼ mm., decentered in.

Q. With the following Rx. O.S. +2.00 ⌒ —.50 ax. 90, O.S. +2.50 ⌒ —.75 ax. 180, you wish to obtain ¾ prism dioptry effect, base in, for each eye. How much must each lens be decentered?

Ans. Prisms base in will be in 180th Md.
Power of O.D. Rx. in 180th is +1.50.
Power of O.S. Rx. in 180th is +2.50.

Formula: $\frac{\triangle \times 10}{P}$ = Decentration in mm.

O.D. $\frac{¾ \times 10}{1.50}$ = 5 mm. to decenter in at Md. 180.

O.S. $\frac{¾ \times 10}{2.50}$ = 3 mm. to decenter in at Md. 180.

Q. A lens is decentered so that the optical center is 4 mm. from the geometric center. It displaces a line 2½ mm. at 25 cm. What is the dioptric power of the lens?

Ans. Since the displacement equals 1/100th part of the distance the prism effect is 1.00△.

Formula: $\frac{\triangle \times 10}{Dec.} = P.$, then $\frac{1 \times 10}{4}$ = 2.50 D. power of lens.

Q. What is a prism diopter?

Ans. A prism diopter is a prism that will bend light 1 cm. in a meter's distance.

Q. State three important uses for prisms in optometry.

Ans. Prisms are used to measure muscular imbalances, are prescribed to relieve eyestrain and are indispensable in giving ocular gymnastics.

Q. How is convergence of the eyes affected by prisms placed base in?

Ans. Prisms placed before the eyes base in would relax convergence.

Q. What would be the effect if prisms were placed temporally before a pair of normal orthophoric eyes?

Ans. Assuming the eyes to be in use and having single binocular vision, the prismatic effect would cause strain on the extrinsic ocular muscles, providing the prismatic effect could be overcome, and single binocular vision maintained. In case the prism effect could not be overcome by muscular effort, an artificial diplopia would result. This artificial created condition is not found in nature.

Q. What prismatic effect would be obtained by placing a 2° prism base down in front of the left eye and a 2° prism base down in front of the right eye?

Ans. Assuming the eyes to be normal and in use, all objects looked at would appear displaced upward.

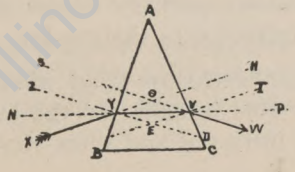
Q. In prescribing prisms for constant wear, would you place the base of the prism over the weak or the strong muscle?

Ans. The base of the prism is placed over the weak muscle. The eye under the prism deviates towards the apex of the prism. The prism bends the light toward its base, and thereby maintains single binocular vision allowing the eye to deviate towards its position of rest, relieving strain on the weak muscle.

Q. Give the prism dioptral power of the prism that will supplement one meter angle of convergence for each eye in a person having an interpupillary distance of 62 mm., and state the position in which it should be placed.

Ans. P.D. in mm. reduced to cm. divided by two will equal the prism dioptral power necessary to supplement each eye for each meter angle, which would be 3.1Δ for each eye, or 6.2Δ for the two eyes. The prism should be placed base out.

Q. Draw a diagram showing the path of a ray of light through a prism and designate the angles of incidence, emergence and deviation.



Ans.

XYZ designates the angle of incidence.

TVW designates the angle of emergence.

SOX designates the angle of deviation, which is equal to HOW.

TVW designates the angle of refraction, which is not always equal to the angle of incidence.

ABC designates the refracting angle of the prism.

Q. What is the prismatic effect of a pair of glasses with a P.D. 6 mm. too wide when the correction is as follows?

O.D. +7.00 sph. ⊃ —3.00 cyl. ax. 90.

O.S. +5.00 sph. ⊃ —2.00 cyl. ax. 90.

Ans. The lenses would both be plus in the horizontal meridian. The O.D. would be +4.00 and the O.S. +3.00. With each eye looking 3 mm. inside of the optical center the prismatic effect on the O.D. would be 1.2° and on the O.S. .9° effect so the total prismatic effect would be 2.1°.

Q. Find the angle of deviation of a prism whose principal angle is 8 degrees and index is 1.62.

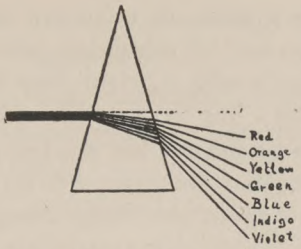
Ans. Multiply angle of prism by its difference of index. $8 \times .62 = 4.96$ degrees, angle of deviation.

Q. What is meant by solar spectrum? Ocular spectrum?

Ans. White light is composed of all the colored lights known, and when it is separated by a prism or other means and thrown on a white screen in a dark room a band of colors resembling a rainbow is seen. This is called a prismatic or solar spectrum. The ocular spectrum is an imaginary spectrum, or color seen by an eye where none exists.

Q. Name the seven primary colors of the spectrum and show how they are refracted in their order.

Ans. Violet is deflected the most; then indigo, blue, green, yellow and orange. Red is deflected the least. There are also invisible rays called infra-red and ultra-violet.



Q. Which position should be given to a prism in order to relieve an ocular muscle?

Ans. A relieving prism should have its base over the inefficient muscle.

Q. What is meant by a prism marked 5$^{\Delta}$?

Ans. A prism marked 5$^{\Delta}$ will deviate light 5 cm. in one meter distance. Ten centimeters in two meters distance, 30 cm. in six meters distance, etc. Known as a 5 diopter prism.

Q. How would you find the deviating power of a prism?

Ans. Multiply the difference of its index by the number of degrees of angle in the prism or by neutralization.

Q. Name the most important advantage of the prism dioptry over the old degree system of numbering.

Ans. The prism-dioptry is a standard deflection of light, produced by a prism, independent of the refractive index of the glass.

Q. A person has a fixed deviation inward of one eye, of three meters angles. What prism power will cause the images to fuse at 100 cm. with a P.D. of 60 mm.? Where would you place the base of the correcting prism?

Ans. There are 6$^{\Delta}$ diopters in a meter angle for the two eyes, or three prism diopters for each eye. It would take six diopters of prism, base out, before the deviating eye.

Q. What prismatic effect would you get by looking through a —5.00 D. sphere 7 mm. below the optical center?

Ans. Three and one-half degrees prismatic effect, base down.

Q. If you have a prism of unknown value whose index is 1.523, how would you find its refracting power?

Ans. Neutralize it with a prism from the trial case or find how much it displaces a line in one meter distance.

Q. What effect on the eye has a prism of 4$^{\Delta}$, base up?

Ans. The eye behind the prism will turn down to an extent equal to 4$^{\Delta}$ if it can, the purpose being to suppress diplopia.

Q. What is the rule for prescribing prisms.

Ans. Prescribe the weakest prism that relieves the strain. The general rule is to prescribe half of the indicated amount divided equally between the two eyes. Prisms should be prescribed with caution, especially in patients under 50 years of age. For patients over 50 years of age prisms should be prescribed when indicated in cases of muscular imbalance, paralysis or paresis of one or more of the extrinsic muscles, and faulty muscle attachments. The regular run of muscular imbalances should be corrected by ocular gymnastics.

Q. Can a prism change the focal length of a lens?

Ans. No. A prism only bends light toward its base.

Q. If a +3.00 D. sph. is decentered up 5 mm., what prismatic power is produced?

Ans. Power times decentration divided by 10 equals 1.5 degrees.

Q. How would you find the power of a lens that has been decentered to give prismatic effect?

Ans. Multiply the prismatic effect by ten and divide by the amount of decentration.

Q. How would you find the amount to decenter a lens to give prismatic effect?

Ans. Multiply the prismatic effect wanted by 10 and divide by the power of the lens.

Q. How would you find the prismatic effect in a decentered lens?

Ans. Multiply the power of the lens by the amount of decentration and divide by 10.

Q. How would you decenter the lenses below to correct three degrees of left hyperophoria?

O.D. —4.00 sph. O.S. —1.00 sph. ⊃ +4.00 cyl. ax. 180.

Ans. Decenter the right lens down 3¾ mm. and decenter the left lens down 5 mm.

Q. How much and which way must a —4.00 D. sph. be decentered to get a two degree prismatic effect, base up?

Ans. Decentered down 5 mm.

Q. If a patient showed for the O.S. —1.00 sph. ⊃ —1.50 cyl. ax. 180 and for the O.S. +50 sph. ⊃ +2.00 cyl. ax. 90, and had 1½ degrees of exophoria and 1 degree of right hyperphoria, how could you correct his muscular trouble without prescribing prisms?

Ans. Decenter the right lens up 4 mm. and the left lens in 6 mm. or the lenses may be decentered obliquely in the 144 meridian, the right lens about 6.2 mm. up and out, and left lens about 5.8 mm. up and in.

Q. A patient 18 years of age has 5.00 D. of hypermetropia and 5^ of esotropia, which way must the lens be decentered to obtain binocular single vision?

Ans. The age of the patient has no bearing on the problem. We are to decenter a pair of plus 5.00 D. spheres so as to offset 5° of esotropia, which is convergent strabismus. Decentering a plus 5.00 D. sphere out 10 mm. produces 5° of prismatic effect, base out. So we increase the P.D. 10 mm., five for each eye, which gives the required prismatic effect.

Q. If a plus 5.00 cyl. ax. 45 be decentered in 6 mm., what is the prismatic power?

Ans. Power in horizontal meridian would be +2.50 times decentration divided by 10 equals 1.5 degrees prismatic effect.

Q. Looking 4 mm. inside of the optical center of a +6.00 D. spherical lens, how much prismatic effect would be produced?

Ans. Two and four-tenths prism diopters.

Q. What is the prismatic power of a plus 3.00 D. lens decentered 5 mm.?

Ans. Multiplying $3 \times 5 \div 10$, we get 1.5^{Δ} as the prismatic effect.

Q. How much would you have to decenter a pair of +2.00 D. lenses in order to correct one degree of heterophoria?

Ans. One lens 5 mm., or each lens 2½ mm.

Q. Which way should a minus lens be decentered to correct esophoria?

Ans. Decentered in.

Q. Which way should a plus lens be decentered to correct exophoria?

Ans. Decentered in.

Q. A person has a fixed deviation outward of one eye equal to 10½ degrees. How many degrees of prism would be required to effect fusion at infinity? Give position of base. Glass used has an index of 1.525.

Ans. 10.5 degrees of deviation divided by excess index .525 equals 20 degrees; base should be in. To prove work, multiply 20 by excess index .525, which gives deviating power of prism.

Chapter V
THEORETICAL OPTOMETRY

Q. How much accommodation would an emmetrope use to focus an object 20 feet away?

Ans. For all practical calculations an emmetropic eye uses no accommodation for 20 feet, although light coming from a distance of 20 feet has a slight amount of divergence and requires about 1/6 of a diopter of plus to parallel it.

Q. What kind of an error of refraction would a plus sphere, combined with a minus cylinder, correct?

Ans. This depends upon the power of the sphere and cylinder. It would correct simple hyperopic astigmatism, compound hyperopic astigmatism or mixed astigmatism according to the power of the combination.

Q. Why is the patient seated 20 feet away from the distance test chart?

Ans. This is a matter of experience. Early in the history of optometry the space available in most offices was about 20 feet, which is considered equivalent to infinity in optometry. It was found that the distance proved satisfactory and was therefore generally adopted.

Q. What is the difference between the optical center and the geometrical center of a lens, and should they always coincide?

Ans. The optical center is a point on the principal axis, and when looked through, there is no prismatic effect. The geometrical center is a point midway between the edges. The two should coincide unless otherwise ordered. When they do not, there is a prismatic effect while looking through the geometrical center.

Q. The correction in a given case is —2.50 sph. ⊃—3.50 cyl. ax. 90 degrees. In which meridian will the stenopaic slit give the best vision, without lenses?

Ans. In this case the error in the vertical meridian is 2.50 D.

of myopia and in the horizontal meridian 6.00 D. of myopia; therefore, vision will be best in the meridian of least error, which is the vertical meridian.

Q. What is the character of the refraction of the eye of a fish while out of water?

Ans. The eye of a fish is highly myopic when out of water, since the index of refraction of the cornea is relatively higher when the fish is in air than when in water.

Q. A lens measure gauged for glass, with a refractive index of 1.523, shows one side of the lens to be —3.00 and the other side as +5.00 but the index of this lens is known to be 1.50. What is the power of this lens?

Ans. To find the power of this lens we combine the surface power, as indicated by the lens-measure, and divide same by the excess index for which the lens-measure was made. This gives the meter curve. Then multiply the M. C. by the excess index of the lens, which gives the true power of the lens.

$$\frac{+2.00}{.523} = 3.824 \text{ M.C.} \times 50 = +1.91 \text{ power of lens.}$$

Q. A patient is presbyopic 1.50 D. and wears for reading on the O. D. +1.00 sph. ⊃+.75 cyl. ax. 80, O. S. +.50 cyl. ax. 110 with which he uses ⅔ of his accommodation. What is his distance correction and amplitude of accommodation?

Ans. Amplitude of accommodation equals three dioptries.
Distance Rx. O. D. +.75 cyl. ax. 80.
O. S. —1.00 sph. ⊃+.50 cyl. ax. 110.

Q. What is the power of the lens required to be placed before the static myopic eye of 2.00 D., in order that an aerial image of its illuminated fundus shall be produced 10 cm. in front of the eye?

Ans. Assuming that we placed the lens on the cornea, it must be a +8.00 D. The eye being myopic 2.00 D. with no lens, the emergent rays would be convergent 2.00 D., but to focus at 10 cm. requires a value of +10.00 D. Hence, by using a +8.00 D. we would get a total plus power of 10 D.

Q. Which can see better, a myope of 1.00 D. or a hyperope of 1.00 D. and under what conditions can they see the same?

Ans. A hyperope of 1.00 D. will see better than a myope of one diopter providing the hypermetropia is facultative, because the former can correct the blur by his accommodation. They will both see alike if their errors are corrected, or if without correction the object looked at is within the far point of the myope.

Q. If a —10.00 D. sphere is placed in front of an emmetropic eye, at what distance in front of this lens may a +2.50 D. sphere be placed in order to see clearly, without accommodation, an object situated at infinity?

Ans. The plus 2.50 D. lens must be placed at such a point that its posterior principal focus will coincide with the posterior principal focal point of the —10.00 D. on the side nearest the eye. The +2.50 sphere must be placed 30 cm. in front of the —10 00 D. sphere.

Q. A person looking at an object 20 inches away through a —4.00 D. sph. ⊂ +5.00 cyl. ax. 25 accommodates one diopter. What is his full correction for distance, made up in simplest form?

Ans. Minus 5.00 D. sph. ⊂ +5.00 D. cyl. ax. 25, which transposed is minus 5.00 D. cyl. ax. 115, would be the simplest form.

Q. A myope of 1.75 D. has lost his power of accommodation. Write Rx. for reading at 16 inches.

Ans. To read at 16 inches requires 2.50 D., the patient is myopic 1.75 D. Therefore, would prescribe plus .75 sph. for reading at 16 inches.

Q. What would be the dioptrical effect in 1 mm. variation in the radius of the cornea, or in the anterior posterior diameter of the eyeball?

Ans. We consider 7.8 mm. as the normal radius for the anterior surface of the cornea, which gives a dioptric value of about 42.00 D. 1 mm. shorter radius would increase its dioptric power 6.00 D., and 1 mm. longer radius would decrease its dioptric power 6.00 D. The eyeball measures about 24 mm. in

diameter. If this be increased 1 mm. it would cause about 3.00 D. of myopia.

Q. Express in diopters the power of a lens whose principal focal distance is seven inches.

Ans. Seven inches equals 177.8 mm. The focal distance into the unit equals 5.624 D.

Q. What is the refractive condition of an eye which has a +3.00 D. sph. in front of it and which is focusing an object 40 inches away, and uses 2.00 D. of accommodation?

Ans. In emmetropia it requires 1.00 D. of accommodation to view an object 40 inches away. This eye is looking through a +3.00 D. sph. and accommodates 2.00 D. Therefore it is hyperopic. The difference between what it should use, 1.00 D., and what it is using, 5.00 D., would equal +4.00 D. of hypermetropia.

Q. What error of refraction would you cause, and would it be with or against the rule, if a plus 2.00 D. cylinder ax. 75 degrees be placed before an emmetropic eye?

Ans. It would cause 2.00 D. of simple myopic astigmatism, against the rule.

Q. How would you express the power of a lens whose principal focus is 14 inches?

Ans. It would be expressed about as a 2.85 D. lens since 14 goes into 40 2.85+ times.

Q. The following is a prescription in which the distance correction for left eye is omitted. Supply it.

Distance correction—

O.D. —.50 D. sph. ⊂ —1.00 cyl. ax. 65.

O.S. missing.

Reading correction—

O.D. +.50 sph. ⊂ +1.00 cyl. ax. 155.

O.S. +3.50 sph. ⊂ —.75 cyl. ax. 65.

Ans. First transpose to make axes alike, which shows that two diopters have been added for reading in the O.D. Assuming that the same amount was added to the O.S., we deduct +2.00 from the reading Rx. of the O.S., which would give +.75 sph.

⌒ +.75 cyl. ax. 155, or +1.50 sph. ⌒ —.75 cyl. ax. 65 as the missing Rx. for the O.S.

Q. A person wearing O.U. +4.00 D. sph. has his P.R. at 27 inches and P.P. at five inches. What is his refractive error, amplitude of accommodation and distance Rx.?

Ans. With the P.R. at 27 inches it would indicate that the +4.00 lens overcorrected his error by 1.50 D.; therefore, his distance Rx. would be +2.50. P.R. equals +1.50. P.P. equals +8.00. The difference between the P.R. and P.P. expressed in diopters equals amplitude of accommodation, which would be 6.50 D. The patient is hyperopic 2.50 D.

Q. The patient's prescription is —2.50 sph. ⌒ +1.50 cyl. ax. 95, and the operator is myopic 1.00 D. What will be the direct ophthalmoscopic finding?

Ans. The operator being myopic 1.00 D., we would algebraically subtract plus one, which would give —3.50 sph. ⌒ +1.50 cyl. ax. 95 as the finding.

Q. About how much difference can be made in glasses when the eyes are not the same focus?

Ans. This can only be determined by actual test. The general rule is not to make a greater difference than two or three diopters, but this is only an average.

Q. If a patient is wearing +2.00 sph. ⌒ —2.00 cyl. ax. 163 and has his P.R. at 27 inches and the P.P. at 8 inches, what is his ametropic correction and amplitude of accommodation?

Ans. The correction would be +.50 sph. ⌒ —2.00 cyl. ax. 163, with an amplitude of 3.50 diopters.

Q. The distance correction is —2.00 D. cyl. ax. 180 degrees and the patient is presbyopic 2.00 D. Write prescription for reading in simplest form.

Ans. Plus 2.00 diopter cyl. ax. 90 degrees.

Q. Would it not be better, in testing eyes, to use daylight instead of artificial light?

Ans. There are two reasons why artificial light is used in testing. One is that the illumination is always the same, re-

gardless of when the test is made, and usually artificial light is more convenient for testing.

Q. Describe a method of determining the principal focal length of a concave spherical lens that does not include the use of a lens measure or neutralizing lenses.

Ans. Form an illuminated spot of light by means of the lens, the source of light being at infinity and small. Hold the lens parallel to the screen and such a distance from it so that the spot of light will be double the diameter of the lens. This distance will be the principal focal length of the concave lens.

Q. At what distance would a plus 4.00 D. sph. index 1.50 focus in water?

Ans. Power divided by excess index equals the M.C. 4÷.50 =8 M.C. Relative index is found by dividing 1.50 by 1.33 (index of water), or 1.1278 as relative index. Excess relative index .1278 times 8 M.C. equals +1.0224 D. power in water. Power divided into our unit 40 gives a focal distance of about 39 inches in water.

Q. After a test for distance has been made, and more than +3.00 must be added for reading, what error can be suspected?

Ans. An error in the distance correction. Although, in cases of amblyopia, it sometimes requires more than three diopters added for reading.

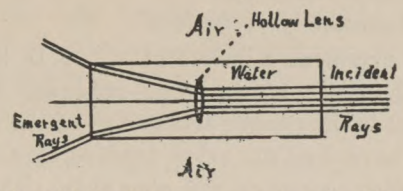
Q. A certain lens has a surface power of minus 1.25 D. on one side and plus 2.50 D. on the other surface. A bifocal segment is added on the minus side to give additional plus of 2.25 D. What curves are required for the wafer and what will be the power of this combination in the reading portion when neutralized?

Ans. The curves on the wafer would be +1.25 D. on the side next to the lens, and +1.00 D. on the other side, the scale added being +2.25 and the lens +1.25 D., which makes a total of +3.50 D. at the reading portion, which would require a —3.50 D. sph. to neutralize.

Q. A hollow double convex lens is made of thin glass index 1.33⅓ and filled with air and placed in a tank of clean water.

Make diagram showing course of rays of light coming from infinity through the lens and after they leave the water.

Ans.



Q. If you should desire to see a small object in five feet of clear water and should dive until your eyes were 18 inches from the object, would you see it clearly? If not, why? Would a lens of any kind assist your vision? If so, what kind?

Ans. No, since water, having the same refractive index as the cornea, would neutralize it, and the eye would be made highly hyperopic. A strong plus lens would assist the vision.

Q. A person looking at an object 10 inches away, through a minus 4.00 D. sph., over +6.00 D. cyl. ax. 45, accommodates 3.00 diopters. What is his full correction for distance?

Ans. Minus 5.00 sph. $\bigcirc$ +6.00 D. cyl. ax. 45. Looking at 10 inches an emmetrope would accommodate 4.00 D. Therefore, this person must be undercorrected one diopter.

Q. If rays of light, starting from 20 inches, focus on the retina of a static eye with a +5.00 D. sph. in front of it, what is the kind and amount of ametropia?

Ans. The eye is hyperopic three diopters.

Q. The refractive index of a certain substance is said to be 1.523. What is the meaning of this statement?

Ans. It means that this substance is optically .523 denser than air, and light falling on this substance will be bent toward the perpendicular. If it strikes at the point of contact obliquely, its speed will also be retarded. The amount of bending is found in the following proportion. Sine of angle in air ÷ by sine of angle in substance as 1.523, or the angle of incidence is to the angle of refraction as the index of the substance is to the index of air.

Q. What is the nearest distance at which the whole size of

a six-foot man can be seen by an emmetrope whose eyes are in a position three feet from the ground and who has the average angles of vision and visual field?

Ans. Approximately three feet.

Q. A lens produces a power of +1.75 D. in the 30th meridian and +2.50 in the 120th. The spherical surface curve is —6.00 D. What is the nature and power of the other surface?

Ans. The nature of the other surface would be convex and toric, as it has two curves on the plus side. The surface power in the 30th meridian would be +7.75 D. value, and the surface power in the 120th meridian would be plus 8.50 D. The formula for this compound would be +1.75 D. sph. ⊃ +.75 D. cyl. ax. 30, and would correct compound hyperopic astigmatism.

Q. How much power of accommodation will an emmetropic eye have to use in order to view its own image in a concave mirror of 40 cm. radius when the eye is 10 cm. from the mirror?

Ans. The eye itself would be considered the object. The wave striking the mirror would be minus 10.00 D., would leave as a minus 5.00 D. wave and focus negative at 8 inches. Then the image would appear to be 12 inches from the eye, and 12 inches would require 3⅓ diopters of accommodation.

Q. If rays of light from 20 inches focus on the retina of a static eye, with a plus 6.00 D. sph. in front of it, what is the kind and amount of ametropia?

Ans. The eye is hyperopic 4.00 diopters.

Q. What error of refraction will the following Rx. correct: O.D. +1.25 D. sph. ⊃ —.87 D. cyl. ax. 180 ⊃ 2° prism, base up?

Ans. Compound hyperopic astigmatism, combined with 2 degrees of right hypophoria.

Q. What lens should be prescribed for an emmetrope whose amplitude of accommodation is 2.00 D. in order that one-fourth of his accommodation may be held in reserve when reading at a distance of 33⅓ cm.?

Ans. Reserving ¼ of his accommodation, he will use ¾ of 2.00 D., which is 1.50 D. It requires a total of 3.00 D. for reading at 33⅓ cm. The difference must be supplied, which will be +1.50 D.

Q. If rays of light, from a distance of 10 inches, are focused on the retina with a +3.00 D. lens without accommodation, what is the refractive error?

Ans. To focus light on the retina coming from 10 inches would require 4.00 D. of plus in emmetropia. If this can be accomplished by means of a +3.00 D. lens the eye must be myopic 1.00 D. and would require minus 1.00 D. sphere for distance.

Far and Near Point

Q. Define the far and near point of vision?

Ans. The far point is the point to which an eye is focused with all accommodation in a state of rest. The near point of vision is the point to which an eye is focused with all its accommodation in use.

Q. What is the near point of vision?

Ans. The near point is the nearest point at which a person can see distinctly, with all accommodation in use.

Q. What will be the near point for a patient who has 2.00 D. of hypermetropia and 8.00 D. of accommodation, with and without the correcting lens?

Ans. A patient hyperopic 2.00 D. requires 2.00 D. of accommodation to focus for distance. If his amplitude of accommodation is 8.00 D., this would leave six diopters in reserve; therefore, the near point without lenses would be six and two-thirds, with correcting lens in place five inches.

Q. On examining a patient you find the P.R. with a plus 3.00 D. lens before the eyes to be at 33⅓ cm. and the P.P. with a —.50 D. lens to be 2000 mm. negative. What is the amplitude of accommodation? The refractive condition? The approximate age of the patient and the correction required?

Ans. The patient is a total presbyope; therefore has no amplitude of accommodation. His refractive condition equals emmetropia. If the presbyopia is physiologic the approximate age is 70 years or more. The patient, being emmetropic, requires glasses for near vision only equal to a pair of +3.00 D. spheres

Q. What is the refractive error of an eye if the near point

while wearing the distance correction is at 4 inches, and with the correction off is at 5 inches.

Ans. Four inches corresponds to ten diopters, while five inches corresponds to eight. The difference between 8.00 D. and 10.00 D. equals the amount of the error, which would be 2.00 D. of hypermetropia.

Q. A hyperope of 3.00 D. has an amplitude of 5.00 D. What lens power would bring his near point to 111 millimeters.

Ans. It would take +3.00 sph. to correct the hypermetropia. This would bring the P.R. into infinity. Now the 5.00 D. of accommodation would bring the P.P. to 8 inches or 200 mm. 111 mm. requires nine D. or 4.00 D. added to the distance Rx. combined with the accommodation, which requires +7.00 D. lens.

Q. A +5.00 D. sph. puts the point of reversal at 26 inches and a +1.00 D. sph. added puts the P.P. at 10 inches. What is the amplitude of accommodation and full Rx., so as to keep half of accommodation in reserve while reading at 16 inches?

Ans. With point of reversal at 26 inches, would show the patient to be hyperopic 3.50 D. Then adding +1.00 D. more would overcorrect the eye 2.50 D. P.P. at 10 inches equals +4.00 D. less the 2.50 D., which the eye is over corrected equals 1.50 D. amplitude. Distance Rx. +3.50 sph. could accommodate .75, but, as it requires 2.50 D. to read at 16 inches, must add +1.75 for reading.

Q. What is the correction for an eye with its far point at 40 inches and its near point at 20 inches? Patient wants two pairs of glasses, one pair for distance and one pair for reading at 13 inches. What would you give?

Ans. With the far point at 40 inches the patient is myopic 1.00 D., so the distance correction would be minus 1.00 D. sph. With P.R. at 40 inches and P.P. at 20 inches the amplitude would be 1.00 D. Allowing the patient to use half of the amplitude, combined with the P.R., which is plus 1.00 D., would equal plus 1.50 D., as it takes 3.00 D. to read at 13 inches. We supply the difference, which would be a +1.50 D. sph. for reading.

Q. If the punctum proximum has receded to 16 inches, what lens power will enable the eye to see at 8 inches?

Ans. With the P.P. at 16 inches, the amplitude must be 2.50 D. To see at 8 inches requires 5.00 D. The difference between 2.50 D. and 5.00 D. is 2.50 D. Therefore the power needed would be a +2.50 sph.

Q. A hyperope of 2.75 D. has an amplitude of accommodation of 4.50 D. Where is his P.R. and P.P. while wearing a +3.25 D. sph.?

Ans. The +3.25 D. sph. would overcorrect the hyperopic .50 D. and cause the eye to be artificially myopic .50 D. Therefore the P.R. would be 80 inches. To find the P.P. we combine the P.R. or +.50 with the amplitude 4.50, which equals +5.00 D. as P.P., or when reduced to inches would be as many inches as 5 D. is contained in our unit 40, which gives 8 inches as the near point.

Q. What lens power should be prescribed for a myope of 1.50 D. whose amplitude of accommodation is 1.00 D. in order that one-fourth of his accommodation may be held in reserve while reading at 33⅓ cm.?

Ans. A myope of 1.50 D. has his P.R. at 27 inches, which equals +1.50. An amplitude of 1.00 D. to hold one-fourth in reserve would be .25 D. Then he has 1.75 D. that is to be used, combined with his P.R. would equal +2.25. To read at 33⅓ cm. requires +3.00 D. Therefore we must supply the difference between +2.25 and 3.00, which would be +.75 D. sph. as his reading Rx.

Q. What is the refractive condition and amplitude of accommodation of a patient whose P.R. with a plus 4.00 D. sph. is 50 cm. and whose P.P. with a plus 1.00 D. sphere is 10 cm.?

Ans. The patient is hyperopic 2.00 D. and the amplitude equals 11 D. The +4.00 D. sph. overcorrects the patient 2.00 D., as his P.R. is at 20 inches. Then the P.P. is taken with a +1.00 D. sph. before the eye, which undercorrects the patient 1.00 D. for distance. With the +1.00 D. in place the P.R. is at 4 inches, which would correspond to 10.00 D. of amplitude. But the eye

must accommodate 1.00 D. for infinity, as it is hyperopic 2.00 D., and is assisted only by +1.00 D. sph.; therefore the amplitude is 11.00 diopters.

Q. An eye exerting full accommodation of 5.00 D. has a negative P.P. of 100 cm. What is the refractive error?

Ans. Hyperopic, six diopters.

Q. A patient's P.R. in the 180th meridian is 27 inches negative. The P.R. in the 90th meridian is 20 inches positive. The P.P. in the 90th meridian is ten inches. Find amplitude of accommodation, punctum proximum in 180th meridian, and distance Rx.

Ans. Amplitude 2.00 D., P.P. in 180th meridian is at 80 inches positive. Distance Rx. would be —2.00 D. sph. ⊂ +3.50 cyl. ax. 90 or +1.50 D. sph. ⊂ —3.50 cyl. ax. 180.

Q. State the nature and amount of the optical anomally of an eye whose amplitude of accommodation is 5.00 D. and whose punctum proximum is at ten inches.

Ans. The near point being at ten inches means that the eye can add 4.00 D. in accommodation from infinity up to its near point. As it has 5.00 D. available, the case is one of 1.00 D. of hyperopia. In focusing for the near point this eye exerts 1.00 D. to focus distance, and then the 4.00 D. additional brings the near point to ten inches.

Q. With the near point in emmetropia at 33⅓ cm., when the eyes are assisted by a +1.50 D. lens, what is the amplitude of accommodation and what lens power should be prescribed for reading at 33⅓ cm. so as to keep one-third of the accommodation in reserve?

Ans. With the P.P. at 13⅓ inches and a +1.50 D. sphere before the eye, shows the amplitude 1.50 D. To read at 33⅓ cm. requires 3.00 D. To leave one-third of the amplitude in reserve, the patient would have 1.00 D. that could be used. So we add the difference between 1.00 D. and 3.00 D., which would give us a reading Rx. of plus 2.00 D. sph.

Q. If the near point of an eye is 5 inches without glasses

and 8 inches with full correction on, what is the approximate error of refraction?

Ans. The near point at five inches equals eight diopters. The near point at eight inches equals five diopters of amplitude. The difference between the two amounts indicates the error of refraction. Uncorrected it has three diopters too much power. Therefore myopia of that amount.

Q. What is the focal length of a lens required by an eye whose far point is 10 cm. in order to see objects clearly at a distance of 25 cm.?

Ans. An eye whose far point is at 10 cm. is myopic 10 diopters. In order to see distinctly at 25 cm., the myopia must be reduced to 4.00 D. or less. Therefore the lens required to do this is —6.00 D., which has a principal focal length of 6⅔ cm.

Q. A presbyope has his near point at 25 cm. and wishes to read comfortably at 8 inches and use half of his amplitude of accommodation. What power of lens would you supply?

Ans. The patient has an amplitude of 4.00 D. Half of this equals 2.00 D. To read at 8 inches requires 5.00 D. Therefore plus 3.00 D. sphere should be supplied.

Q. If a hyperope of 2.00 D. has his near point at 80 inches, what is his amplitude of accommodation?

Ans. The amplitude would be 2.50 D. Age 50 years, full correction would be +2.00 D. sph. for distance with +1.75 D. added for reading.

Q. A myope of three diopters has an amplitude of accommodation of two diopters. What lenses should be prescribed for viewing objects 50 cm. away in order to permit the use of one-fourth of the accommodation?

Ans. An eye focused at 50 cm. requires 2.00 D. of plus. Without glasses this patient is myopic 3.00 D. Therefore we must reduce the myopia from 3.00 D. to 2.00 D. In addition, he is to use one-fourth of his accommodation, which will be .50 D., so the total power of lens required is —1.50 D.

Q. State where the punctum proximum of a hyperopic eye of three diopters in a person 50 years of age is located.

Ans. Assuming that the patient has an amplitude of 2.50 D., which would be normal for that age, the punctum proximum would be negative 80 inches.

Q. What is the refractive error of an eye if the near point is at ten inches without glasses, while with correcting lenses it is at 13 inches?

Ans. The patient is myopic 1.00 D., as the near point is ten inches, without glasses corresponds to 4.00 D. While with correcting lenses the near point is 13 inches, which corresponds to 3.00 D., showing the eye to be myopic 1.00 D.

Q. What Rx. would an emmetrope require for reading if his near point is at 13 inches?

Ans. The only way to tell exactly is to use one of the dynamic tests, but it can be estimated as follows: A near point of 13 inches for an emmetrope shows that the amplitude of accommodation is 3.00 D. Of this about one-half should be held in reserve, so the amount of accommodation available is 1.50 D., as a reading distance of 13 inches is always assumed, and this corresponds to 3.00 D. Therefore we must add enough to the 1.50 D. supplied by the accommodation so as to make a total of 3.00 D., which will be +1.50 D.

Q. The near point of the 180th meridian of an eye is positive 16 inches and the far point is negative 13⅓ inches. What is the refractive error, amplitude of accommodation and full correction?

Ans. Assuming that the vertical meridian is emmetropic, the error is one of simple hyperopic astigmatism, and is corrected by a plus three diopter cylinder, axis 90 degrees. The amplitude of accommodation is 5½ D.

Q. What is the dioptric interval called between the near point and far point of an eye?

Ans. This interval is called "amplitude of accommodation."

Q. What is the amount and nature of the optical anomally of an eye whose near point is at 25 cm. and whose amplitude of accommodation is 5½ D.?

Ans. The near point at 25 cm. corresponds to 4.00 D. of accommodation. Therefore the eye must be hyperopic 1½ diopters.

Q. Find the amplitude in each of the following cases: (a) An emmetrope whose near point is 12.5 cm. from the eye. (b) A myope of 3.00 D. whose near point is at 11.1 cm. from the eye. (c) A hyperope of 3.00 D. whose near point is 12.5 cm. in front of the eye.

Ans. (a) Eight diopters, 12.5 cm. divided into the unit 100 cm. (b) Six diopters, 11.1 cm. divided into the unit 100 cm., less the 3.00 D. of myopia. (c) Eleven diopters, 12.50 cm. into the unit 100 cm. plus the three diopters of hypermetropia.

Q. What effect does age have upon the far and near point?

Ans. Age causes the near point to recede until it coincides with the far point. Old age causes both points to recede. For instance, a person who is emmetropic in youth may have a near point of four or five inches. As he grows older this will recede until the time when he is about seventy years of age the near point and far point may be at the same place, at infinity, or negative.

Q. An eye exerting full accommodation of 5.00 D. has a negative punctum proximum of 200 cm. Write Rx. for refractive error.

Ans. The patient is hyperopic 5.50 D. and requires plus 5.50 sphere for constant wear.

Q. What is the punctum remotum of a hyperope of 4.00 D. who has 7.50 D. of accommodation?

Ans. The amplitude of accommodation has nothing to do

with the far point. The fact that the patient is hyperopic 4.00 D. will make his far point negative, and at a distance of 10 inches from the eye. This is an imaginary point back of the eye.

Q. In measuring the amplitude of accommodation and the power of convergence, what points must be determined?

Ans. The far point and the near point of refraction and convergence.

Q. If a patient age 30 years has the near point of the 90th meridian at 20 inches, and the near point of the 180th meridian at 6⅔ inches, what is the error of refraction? Write Rx.

Ans. At the age of 30 years the average amplitude is seven diopters. With the near point in the 90th meridian at 20 inches, equals 2.00 D. Therefore the 90th meridian is —5.00 D. or hyperopic 5.00 D. The horizontal meridian is —1.00 D. or hyperopic 1.00 diopter. Taking this from the cross, our prescription would be +1.00 sph. ⊃ +4.00 cyl. ax. 180. Which would correct compound hyperopic astigmatism.

Q. What is the refractive error of an eye if the P. P. without distant glasses is four inches, while with glasses, it is five inches?

Ans. With the near point closer without distance glasses, would indicate that the case is one of myopia. Four inches equals 10.00 D., and five inches equals eight diopters of amplitude. The patient is myopic 2.00 D.

Q. A patient when assisted by +1.00 D. lens has the P. P. at 25 cm. What lenses will be required in order to retain ⅓ of his accommodation in reserve while reading at 33⅓ cm.?

Ans. The patient has an amplitude of 3.00 D., ⅔ of 3.00 D. equals 2.00 D. which could be used, and as it takes 3.00 D. to read at 33⅓ cm. the patient lacks one D. So plus one D. spheres should be prescribed for reading.

Q. The P. R. of the 180th meridian of a static eye is positive 20 inches and P. R. of 90th meridian is negative 10 inches.

What is the refractive error called and what lens will correct it?

Ans. The refractive error is one of mixed astigmatism.

Rx. +4.00 D. sph. ⊂—6.00 D. cyl. ax. 90.
—2.00 D. sph. ⊂+6.00 D. cyl. ax. 180.

Q. Where is the far point of a hyperope who has 3.00 D. of accommodation and whose near point is situated at ½ meter?

Ans. The far point would be situated 40 inches negative or behind the retina. The patient is hyperopic 1.00 D. and requires plus 1.00 D. sph. for distance.

Q. What relation has the punctum remotum to the degree of ametropia? The punctum proximum?

Ans. The farther away from infinity the punctum remotum expressed in diopters the greater the error of refraction. In any given case the punctum proximum will be closer in myopia and farther away than it should be in hypermetropia.

Q. What is the amplitude of accommodation of a myope of 5.00 D. whose near point is at 10 cm.?

Ans. A five diopter myope has far point at 20 cm., equals +5.00 D. The near point being at 10 cm. equals +10 D. The difference between the far and near point expressed in diopters equals the amplitude of accommodation which in this case would equal five diopters.

Q. A person wearing +4.00 sph. ⊂+1.00 cyl. ax. 90 has his far point at 20 inches, and his near point at four inches. What is his proper correction and amplitude of accommodation?

Ans. Since his far point is at twenty inches this lens has made him myopic 2.00 D. To correct this error a —2.00 sph. is required. Adding this to the lens we get +2.00 sph. ⊂+1.00 cyl. ax. 90 which is his proper ametropic correction. To get the amplitude of accommodation we take the difference of refraction between the far and near points. Dioptric equivalent

of 20 inches, is 2.00 D. and of four inches is 10.00 D. His amplitude of accommodation is therefore 8.00 D.

Q. What is the range of accommodation of a 2.00 D. hyperope with a near point of 16 inches? What is his amplitude of accommodation?

Ans. The range of accommodation would be from infinity to 16 inches. The amplitude of accommodation is 4.50 D.

Q. Give near point and amplitude of accommodation from 10 to 75 years.

Ans. See Tables.

Chapter VI

OCULAR REFRACTION

Q. What is emmetropia?

Ans. Normal or perfect refraction of an eye. That condition in which the static refraction is adjusted for parallel light.

Q. Does an emmetrope always have normal vision?

Ans. No. Emmetropia has no reference to sight or disease, but simply means that the optical apparatus has the correct focal length for the globe of the eye. The refractive media may form a perfect image on the retina; yet there may be some defect which interferes with its transmission to the brain, or the brain may be unable to interpret the impulse. The eye may be amplyopic or its refracting media may be opaque.

Q. How can you prove by the trial case test that an eye is emmetropic?

Ans. Fog the patient, then reduce the fog gradually. If weak plus blurs best vision and minus power does not improve vision, the astigmatic dial is uniform and vision remains the same while the stenopaic slit is slowly turned through the different meridians, the eye may be considered emmetropic.

Q. Describe what is seen in emmetropia and all forms of ametropia in the cobalt blue test.

Ans. In emmetropia the light appears an even pinkish purple hue. In hyperopia a blue center with a red border. In myopia, a red center with a blue border. Comp. H.A. blue center and red border, with red more distinct in one meridian. Comp. M.A., red center and blue border with blue more distinct in one meridian. Simple H.A. blue center with red border in one meridian. Simple M.A. red center with blue border at right angles. Mixed A., a heavy blue streak with red border in one meridian and blue border at right angles.

Q. What is ametropia?

Ans. Any refractive defect of the eye.

Q. Under what three heads may ametropia be subdivided?

Ans. Astigmatism, hypermetropia and myopia.

Q. In what form of ametropia are the ciliary muscles most developed? Least?

Ans. The ciliary muscles are usually most developed in hypermetropia. The least in myopia and in high degrees, almost entirely undeveloped.

Q. In cases of high ametropia, by what means may a prognosis of an improvement in vision be made without the use of lenses?

Ans. By means of the pin-hole disc.

Q. What determines the degree of ametropia?

Ans. The power of the refracting surfaces, density of the refracting media, the distance between the refracting surfaces, together with the location of the retina.

Q. What ametropic condition would admit of 20/13 vision, and why should it be corrected?

Ans. Hyperopia, where the deficiency in the refractive media of the eye can be made up by plus lenses, instead of using the accommodation, thus relieving asthenopia and restoring normal conditions.

Q. Would you correct ametropia if the visual acuity is normal? If so, why?

Ans. Yes. To relieve strain and to prevent the overtaxation of the nervous system.

Q. In correcting ametropia, how far from the cornea must the lens be placed, so that the image formed in the retina will be the same size as in emmetropia?

Ans. Each lens should be in the first focal plane of the eye—that is, 13.7 mm. in front of the cornea. When this is the case, the image formed in the retina will be the same size as in emmetropia.

Hypermetropia

Q. What is hypermetropia?

Ans. Hypermetropia is that condition of the eye in which the static refraction is too weak, and may be classified as original and acquired.

Q. Give ten results which may be caused by hypermetropia.

Ans. Headache, blepharitis, chalazion, hordeolum, chronic conjunctivitis accompanied by epiphora and photophobia, glaucoma, asthenopia, or tired and painful vision, esotropia or esophoria, and nervousness due to eye strain. It also hastens presbyopia.

Q. What is the general rule for correcting hyperopia?

Ans. Give the strongest plus lens, with which the patient has best vision at six meters.

Q. What is the acquired hypermetropia?

Ans. Hypermetropia that develops after birth, usually after presbyopia is present, or after the crystalline lens has been removed.

Q. What are the causes of hypermetropia?

Ans. (a) Too short anterior-posterior length of the eyeball. (b) Too small a convexity of the lens. (c) Too small a convexity of the cornea. (d) Too small a difference between the densities of the aqueous and lens. The lens and vitreous, or both. (e) Absence of lens, known as aphakia.

Q. What difficulty is sometimes encountered in attempting to correct fully a case of hypermetropia?

Ans. In some cases of hypermetropia the ciliary muscle has been overactive so long that it cannot adapt itself readily to the normal condition of being at rest for distant vision. The usual practice is to give a full correction and instruct the patient to wear same constantly and the glasses will prove satisfactory.

Q. What is meant by facultative hypermetropia, and what are the bad results that may be produced by it?

Ans. Facultative hypermetropia is that part of the hypermetropia that can be overcome by the accommodation. This form of hyperopia causes disturbance in the nervous system,

which becomes manifest in asthenopia, headaches, eyestrain, esophoria and sometimes causes esotropia.

Q. Why are the hyperopes given the strongest convex lenses they will accept?

Ans. The hyperope should be given the strongest convex lens that does not blur his best distant vision. A weaker lens would make it necessary for the accommodation to act and cause eye strain.

Q. Do low errors of hypermetropia cause eye strain?

Ans. Low errors of hypermetropia often cause the most ocular discomfort. The refractionist should be careful and painstaking in making the examination at all times.

Q. What error of refraction is most apt to cause spasm of the ciliary muscles?

Ans. Hypermetropia, because the ciliary muscles are overworked.

Q. Do we always improve sight in correcting hypermetropia?

Ans. Not when the hypermetropia is facultative. Lenses cannot improve vision when the focus is on the retina.

Q. When is hypermetropia said to be absolute?

Ans. When it cannot be neutralized by the accommodation, either because the defect is of too high a degree, or the accommodative power is too weak as a result of age or weak ciliary muscles. Under such conditions vision is impaired at all distances, especially near vision.

Myopia

Q. What is myopia?

Ans. Myopia is that condition of the eye in which the static refraction is too strong.

Q. Give six different conditions which may result from myopia.

Ans. Detachment of the retina, exotropia, destructive choroiditis, exophoria, progressive and malignant myopia.

Q. What is the general rule for correcting myopia?

Ans. Give the weakest minus lens with which the patient can read normal at six meters.

Q. What is acquired myopia?

Ans. Myopia which is developed through occupation or otherwise, as in poorly lighted rooms.

Q. What is brachymetropia?

Ans. The same as myopia and hypometropia. It is that condition of the eye in which the static refraction is too strong. Parallel rays of light will focus in front of the retina with the muscles of accommodation in a state of rest.

Q. In what way do myopia and spasm or the accommodation resemble each other?

Ans. In both conditions the far point is nearer than infinity and the visual acuity is not normal for distant vision and both are improved by minus lenses.

Q. Why are myopes given the weakest concave lenses with which vision is normal at 20 feet?

Ans. Myopes are given the weakest minus lenses that will produce normal vision, as a stronger lens may be an overcorrection and cause strain on the ciliary muscles.

Q. Name causes of myopia.

Ans. Too long an anterior-posterior diameter of the eyeball. Too great a convexity of the lens. Too great a convexity of the anterior surface of the cornea. Too great a difference between the densities of the cornea and lens, the lens and vitreous or both. Swelling of lens, being one of the early changes in the lens in senile cataract.

Q. Name two kinds of myopia and describe each.

Ans. Myopia is divided into progressive and stationary. Progressive myopia is a diseased condition in which the myopia increases and may lead to blindness. Stationary myopia is usually refractive, due to the radius of curvature of the lens or cornea being too short.

Q. To what is functional myopia due?

Ans. Functional myopia is due to spasm of the ciliary

muscle, swelling of the lens, as in incipient cataract and conical cornea.

Q. How is pseudo or false myopia produced?

Ans. By a tonic spasm of the ciliary muscles.

Q. What error of refraction may be present when pseudo myopia is detected?

Ans. Hypermetropia and in rare cases the patient is emmetropic.

Q. A myope of 13 D. has the crystalline lenses removed. What lenses would enable him to read at 33⅓ cm.?

Ans. If an eye is emmetropic and the lens is removed it becomes highly hyperopic, to an extent at the surface of the cornea of about 12 D. The correcting lens, however, is placed approximately 15 mm. in front of the cornea, so that the condition can be neutralized by a lens of about 10 D. of plus. It would be difficult to calculate the exact refractive condition without making the test in the above case. It may, however, approach near emmetropia for distant vision. After the crystalline lens is removed there is usually very slight accommodative power. Therefore, for reading it would require about 2.75 D. of plus.

Q. What is the direction of the rays of light reflected from the illuminated fundus of a highly myopic eye, when viewed by means of an ophthalmoscope?

Ans. The rays reflected from an illuminated fundus of any eye, no matter what its refractive condition, will be diverging except the center or axial ray, which is reflected back parallel.

Q. In making a rapid preliminary test, what would cause you to suspect high myopia?

Ans. Greatly impaired distant vision and good near vision.

Q. What would you do with a case of malignant myopia?

Ans. Give full or slight overcorrection to be worn continually and advise patient to use eyes for close vision as little as possible. If much reading is necessary make an extra pair to be worn only for close vision, undercorrecting the myopia to make accommodation comfortable and combine with weak prisms, base in, to relieve part of the convergence.

Q. Name the four clinical forms of myopia.

Ans. Stationary, functional, progressive and malignant myopia.

Q. What is stationary myopia?

Ans. Stationary or true myopia is the term applied to the ordinary variety which is usually due to excessive curvature or density or both of the refractive media, of the eye. Sometimes called refractive or curvature myopia.

Q. What is malignant myopia?

Ans. Malignant myopia is progressive myopia when it runs a rapid course ending in blindness.

Q. What is progressive myopia?

Ans. Progressive myopia is that form in which the error increases from time to time, accompanied by destructive changes in the choroid and by a gradual falling off of distant vision. This condition is usually detected in young patients, but may develop at any age.

Q. A myope of 2 D. has lost all power of accommodation. What lenses should be prescribed for reading at 13⅓ inches?

Ans. To focus at 13⅓ inches an emmetrope without accommodation would need +3.00 D. lens. But in this case the eyes supply +2.00 D.; therefore +1.00 D. is required for reading at 13⅓ inches.

Astigmatism

Q. What is meant by astigmatism?

Ans. The word astigmatism means without a point. It is due to unequal curvature of the cornea or crystalline lens or both. Astigmatism is an error of refraction which is not the same in all parts of the eye.

Q. Why does oblique astigmatism cause more disturbance to vision than astigmatism that is vertical or horizontal?

Ans. It causes more or less disturbance of the oblique recti muscles, and induces cyclophoria.

Q. What is meant by astigmatism with the rule and against the rule?

Ans. If the correction be a convex or plus cylinder with

axis 90 degrees or within 45 degrees of 90, or a minus cylinder, with axis at 180, or within 45 degrees of 180, it indicates astigmatism with the rule. Plus cylinders with axis at 180 degrees or within 45 degrees of 180, or minus cylinders with axis at 90 degrees or within 45 degrees of 90 indicate astigmatism against the rule.

Q. What parts of the eye may be at fault when astigmatism is present?

Ans. The cornea, the crystalline lens, and possibly both.

Q. Would you always give full correction in mixed astigmatism? Give reasons.

Ans. No. In apparent mixed astigmatism, when the correction gives normal vision or better. For example: +1.00 sph. ⊃ —1.25 cyl. ax. 180, which transposed is —.25 sph. ⊃ +1.25 cyl. ax. 90. Leave off the minus sphere and prescribe the plus cylinder alone. It will be found in most cases that vision will improve after wearing the plus cylinders. Thus proving the mixed astigmatism false, and that it is a case of simple hyperopic astigmatism.

Q. What is irregular astigmatism?

Ans. Irregular astigmatism is a condition where the surface of the cornea varies and the refraction differs in the same meridian.

Q. What causes irregular astigmatism?

Ans. Irregular astigmatism is generally caused by injuries, or it may be due to inflammation.

Q. What is mixed astigmatism?

Ans. Mixed astigmatism is a condition where the eye is myopic in one meridian and hyperopic in the other meridian, at right angles.

Q. Name the several varieties of astigmatism.

Ans. There are five varieties of regular astigmatism. Simple myopic, compound myopic, simple hyperopic, compound hyperopic, and mixed.

Q. What is the cause of physiologic astigmatism?

Ans. This variety of astigmatism is due to excessive lid

pressure, or temporarily to extreme pulling or contraction of the extrinsic muscles. Chalazion is also a common cause. This form of astigmatism is not constant.

Q. What causes most trouble, astigmatism with the rule or against the rule?

Ans. A small amount of astigmatism against the rule causes more trouble than a greater amount with the rule.

Q. What lens corrects astigmatism?

Ans. Astigmatism is corrected or neutralized by means of the cylindrical lens, which makes all meridians the same power.

Q. What is the difference between regular and irregular astigmatism?

Ans. Regular astigmatism is an error of refraction in which one meridian differs from another. Irregular astigmatism is an error of refraction where there is a difference of refraction in one and the same meridian.

Q. What is the difference between corneal and lenticular astigmatism?

Ans. Corneal astigmatism is due to the corneal surface being unequal in curvature, while lenticular astigmatism is due to the same cause in the surfaces of the crystalline lens. In either case, if the astigmatism is regular, it is corrected by means of a cylinder.

Q. How is irregular astigmatism divided?

Ans. It is divided into normal and abnormal astigmatism. Normal irregular astigmatism is due to a difference of refraction in one meridian, but not enough abnormal to disturb vision. Abnormal irregular astigmatism is a difference of refraction in different parts of the same meridian, great enough to disturb vision.

Q. Name three methods by which astigmatism may be detected and measured.

Ans. Astigmatism may be detected and measured by the retinoscope and ophthalmometer, which are objective methods. It can also be detected and measured by examination with the trial case, which is a subjective method.

Q. In correcting astigmatism, where would you place the axis of the correcting cylinder if the spokes from 10 to 4 are seen the blackest? State reason why.

Ans. The axis of the correcting minus cylinder should be placed at right angles to the blackest spoke seen. In the above case the axis should be placed at 120 degrees, because a cylinder focuses the rays of light in the meridian corresponding to its axis.

Q. Is lenticular astigmatism generally with or against the rule? How does it affect the findings with the ophthalmometer?

Ans. Against the rule. It does not affect the ophthalmometer findings.

Q. What is homonymous astigmatism?

Ans. Homonymous astigmatism is the condition in which the cylinder axis in each eye are the same.

Q. What is heteronymous astigmatism?

Ans. Heteronymous astigmatism is the condition in which the astigmatism in one eye is with the rule and in the other eye against the rule. Example: O.D. +3.00 cyl. ax. 90°, and O.S. +3.00 cyl. ax. 180°.

Q. What kind of astigmatism can be detected by means of the ophthalmometer?

Ans. Corneal astigmatism. It may be regular or irregular.

Q. How is irregular astigmatism corrected?

Ans. Irregular astigmatism is that curvature of the refractive media of the eye, which cannot be made truly spherical by means of a cylinder. It can be overcome by means of the pin hole disc, the aperture of which is shifted from point to point in front of the pupil, until best vision is obtained. The prescription should be made up with the lens frosted except a small aperture in the central portion in high amounts.

Q. In low degrees of astigmatism in the vertical meridian, while looking at cross lines, one set vertical and the other horizontal, the patient sees them both alike. If low powered cylinders are placed in front of the eyes, they still look alike. How would you account for this?

Ans. This is no doubt due to an active accommodation. The patient should be fogged with plus spheres. When the fog is gradually reduced the true condition should show on the clock dial. Oftentimes this condition is found with astigmatism of any amount. This may be due to poor color vision or some form of amblyopia, and is measured by means of the ophthalmometer and retinoscope objectively, and stenopaic slit and cylindrical lenses subjectively.

Q. What is meant by the principal meridians of an astigmatic eye?

Ans. The meridians of the greatest and of the least refraction. They are usually at right angles to each other 90° apart.

Q. What is the rule for placing cylinders in testing, using the fogging method?

Ans. Place the axis of a minus cylinder at right angles to the blackest line seen on the astigmatic dial. Plus cylinders when used are placed with the axes corresponding to the blackest line seen.

Q. What is oblique astigmatism?

Ans. Astigmatism in which the axis of the correcting cylinder is not vertical or horizontal.

Q. Why do findings sometimes differ in measuring astigmatism by the astigmatic dial, by the stenopaic slit and by the retinoscope?

Ans. The astigmatic dial method tests the eye with the pupil normal in size, with stenopaic slit, the pupil dilates because the disc shuts out light, and this widening brings into play the periphery of the refracting surfaces, which may have a different amount of error from that of the center; so the test will show an astigmatic condition which is a combination of the two. The retinoscope does not measure along the visual axis and so gives the amount of ametropia of a part of the eye that is not the same as that tested by the other two methods. Therefore the results may be slightly different.

Q. How would you know the cylinder used was of proper strength, or an under or over correction, in the case of astigmatism, with the trial case test?

Ans. When the astigmatic dial is used in the fogging method the weakest minus cylinder that makes the dial uniform, and at the same time gives best vision, is considered the full astigmatic correction. As long as the dark or plainest spoke remains so, it would indicate an undercorrection, and when the dark spoke reverses and the dimmest spoke becomes the darkest or plainest, it indicated an overcorrection.

Q. What is homalogous astigmatism?

Ans. Homalogous astigmatism is symmetric astigmatism with the rule. Example: O.D. +2.00 cyl. ax. 75°, O.S. +2.00 cyl. ax. 105°.

Q. What is heterologous astigmatism.

Ans. Heterologous astigmatism is symmetric astigmatism against the rule. Example: O.D. +2.00 cyl. ax. 30°, O.S. +2.00 cyl. ax. 150°.

Q. By how many different means can you determine the existence of astigmatism, the amount and axis?

Ans. Astigmatism may be detected, and the amount and axis calculated by the following means. Retinoscope, ophthalmometer, stenopaic slit, astigmatic clock dial, cylindrical lens, and Lorenz cobalt blue test. It can also be estimated by the ophthalmoscope, direct method.

Q. In case of compound astigmatism, if the vertical meridian is neutralized, in what direction will the band extend?

Ans. The band, or straight edge, extends in the direction of the neutralized meridian; therefore, the band would extend vertically.

Q. How would it be possible to test a case of compound hypermetropic astigmatism, with spherical lenses only?

Ans. By the use of spherical lenses, in conjunction with the stenopaic slit or retinoscope and examining each of the principal meridians separately.

Q. In simple myopic astigmatism, how could you use a plus cylinder?

Ans. By transposing the minus cylinder to its equivalent

compound, which would show a plus cylinder at the opposite axis, combined with a minus sphere.

Q. To what extent should astigmatism be corrected?

Ans. The rule is to make a full correction, but in some cases, where the error is high, a partial correction is all that will be accepted with comfort in the first pair of glasses.

Q. What is the difference between astigmatism and aberration?

Ans. Aberration, when applied to a positive spherical lens or lens system, would mean the blur and distortion caused by an imperfect focus, due to the peripheral rays focusing nearer the lens than those refracted by the central portion. The degree of aberration increases with the size and power of the lens; also the distance and location of the object. A double convex lens has the greatest amount. A meniscus the least. A Punktal lens is free from blur and distortion. Astigmatism is a visual defect due to unequal curvature of one or more of the refracting surfaces, causing unequal refraction in various meridians, which cause blur and distortion. The rays passing through the meridian of greatest curvature have a shorter focus than those passing at right angles through the meridian of least curvature, which have a longer focus; therefore, cause an imperfect focus.

Q. What is the difference between corneal and lenticular astigmatism? What difference, if any, should be made in the correction of each?

Ans. Corneal astigmatism is due to an unequal curvature in the cornea. Lenticular astigmatism is due to an unequal curvature in the crystalline lens. There are two theories advanced in regard to correcting astigmatism; one is to correct the corneal astigmatism only, as indicated by the ophthalmometer and not prescribe a cylinder when the cornea is spherical. The other is to prescribe a cylinder when indicated by the retinoscope and astigmatic dial, providing the cylinder improves vision. Cylinders should always be proved up by the subject test. The aim is to give comfortable and best vision.

Q. Where is the principal seat of astigmatism?

Ans. The principal seat of astigmatism is at the anterior surface of the cornea.

Q. What would be the astigmatism if at meridian 90 the radius of curvature of the cornea is 7.5 mm. and at 180 meridian 8.25 mm.? What lens, 15 mm. in front of the cornea, would correct such a defect?

Ans. Reducing the radii to cm., we have .75 for 90th and .825 for 180th. Take index of refraction of the cornea at 1.33, then dioptric power of 90th meridian equals $\frac{.33}{.75} = 44$, 180th meridian equals $\frac{.33}{.825} = 40$. The astigmatism therefore is 4.00 D., with the rule and would be corrected by a +4.00 cyl. ax. 90. The ophthalmometer would give the amount of error as 4.00 D., the reading being for a lens placed on the cornea. To obtain the power of the correcting lens at 15 mm. a deduction of .25 must be made. The correcting cylinder at 15 mm. will therefore be +3.75 cyl. ax. 90.

Q. Write a cross cylinder prescription to correct a case of mixed astigmatism.

Ans. Such a prescription would be +1.25 cyl. ax. 90 ⊃ —1.75 cyl. ax. 180.

Q. How is the stenopaic slit used in a case of astigmatism?

Ans. With the trial frame or phorometer in place, the stenopaic slit inserted in the front cell, and rotated until the meridian is found of least refraction, where patient can see best. Then spheres are added until the best vision is obtained. Make a cross and place the findings on the arm to correspond with the meridian examined. Then rotate the slit 90 degrees and proceed in the same manner. Write Rx. from the cross.

Q. What is the most common form of astigmatism?

Ans. Hyperopic astigmatism with the rule.

Q. A patient has 4.00 D. of myopic astigmatism, the verti-

cal meridian having the most power. What lens will correct the astigmatism?

Ans. Minus four dioptric cylinder axis 180 degrees, or —4.00 D. sph. ⊃ +4.00 D. cyl. ax. 90.

Q. How would you produce 1.50 D. of artificial myopic astigmatism, in the 165th meridian of the eye?

Ans. By placing a plus 1.50 D. cyl. before the eye, with its axis at 75 degrees.

Q. When the horizontal lines of the astigmatic chart are most distinct with no lens before the eye, at what axes should the correcting cylinder be placed in a case of simple myopic astigmatism?

Ans. The axis of the minus cylinder should be placed vertical or at 90 degrees.

Q. In myopic astigmatism how would you place the axis of a plus cylinder?

Ans. If a plus cylinder is to be used in myopic astigmatism, its axis should be placed over the blackest spoke seen on the astigmatic clock dial.

Q. Does astigmatism usually change in adults?

Ans. No; the total amount of true astigmatism rarely changes.

Q. What difference exists in the correction in the two principal meridians in compound myopic and compound hyperopic astigmatism respectively?

Ans. In compound myopic astigmatism the meridian of least refraction requires the weaker correction and the meridian of greatest refraction requires the stronger correction; whereas in compound hyperopic astigmatism the meridian of least refraction requires the stronger correction and the meridian of greatest refraction requires the weaker correction.

Q. If an eye has 2.00 D. of hypermetropic astigmatism in the vertical meridian and you place a plus 2.50 D. sphere in front of the eye, what formula will correct the artificial condition thus produced?

Ans. The condition thus produced would be one of compound myopic astigmatism.

Rx. —.50 sph. ⊂ —2.00 cyl. ax. 90.
—2.50 sph. ⊂ +2.00 cyl. ax. 180.

Q. If an eye has 1.00 D. of hyperopic astigmatism in the horizontal meridian and you place a +1.25 sph. in front of it, what is the correction for the artificial condition thus produced?

Ans. The plus 1.25 sph. would make the vertical meridian myopic 1.25 D. and the horizontal meridian myopic .25 D. Therefore the correction would be minus 1.25 sph. ⊂ +1.00 cyl. ax. 90, or —.25 sph. ⊂ —1.00 cyl. ax. 180.

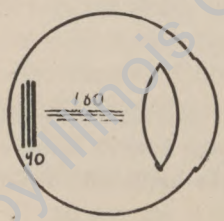
Q. Which meridian of the cornea has the greatest curvature in an astigmatism of +2.00 D. cyl. ax. 90?.

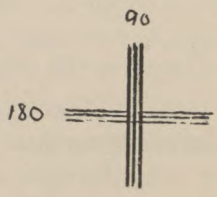
Ans. The 90th meridian has the greatest curvature, as the plus power is required in the 180th meridian.

Q. Why do some people with an astigmatic error and using their naked eyes see the horizontal lines on the chart distinctly, but with fogging lenses they see the vertical lines plainest, while others see the same lines plainest with or without the fogging lenses?

Ans. If the refractive error is hyperopic astigmatism, the plain or blackest lines on the astigmatic chart will reverse under fog. In myopic astigmatism the same lines remain blackest with or without fogging lenses. They are seen as they are focused on the retina. The plainest spokes seen are focused nearest the retina, and the blurred spokes are focused farthest away from the retina.

Q. Show by diagram how the patient sees the astigmatic clock dial in astigmatism and explain.





Ans. The diagram illustrates a case of compound myopic astigmatism with the rule. Patient sees the vertical lines of the chart plainest and horizontal lines blurred. The principal meridians in the eye are therefore 90 and 180. Light rays reflected from the horizontal lines are refracted by the vertical meridian of the eye as through a convex cylinder axis 180, and are brought to a horizontal line focus. This focus is farthest from the retina since the 90th is the strongest refracting meridian, and therefore the horizontal lines in the chart appear dim. Rays reflected from the vertical lines in the chart are refracted by the horizontal meridian of the eye, as through a convex cylinder axis 90, and are brought to a vertical line focus. This focus is nearest the retina, since the 180th is the weakest refracting meridian, and therefore the vertical lines in the chart appear plainest. To correct the astigmatism it would require a minus cylinder axis 180 or a plus cylinder axis 90.

Q. Explain how the axis of plus and minus cylinders should be placed, with and without a fog.

Ans. With fog the axis of a minus cylinder should be placed at right angles to the plainest spoke in the wheel. Plus cylinders are not used in the fogging method, but if they were, the axis would have to be placed parallel with the plainest spoke.

Without fog the axis of a minus cylinder should be placed parallel with the plainest spoke, although plus cylinders are generally used. Axis of plus cylinders must be placed at right angles to the plainest lines in the wheel.

Q. By subjective optometry, if a patient has half a diopter of hyperopic astigmatism, axis 90 degrees, and looks at the astigmatic wheel through a minus 1.25 diopter lens, which lines will appear plainest?

Ans. With the eye in a static condition, the patient would see the horizontal lines the plainest, lines from 3 to 9 on the dial.

Q. What is symmetric astigmatism?

Ans. Symmetric is that kind where each eye requires a cylinder and the sum of the two axes equal 180, or 90. A sym-

metric is that kind where both eyes are astigmatic, and the sum of the two cylinder axes does not equal 180 or 90.

Q. Show by diagram and explain how the astigmatic dial appears to a patient who has astigmatism and show how the principal meridians are focused in the eye.

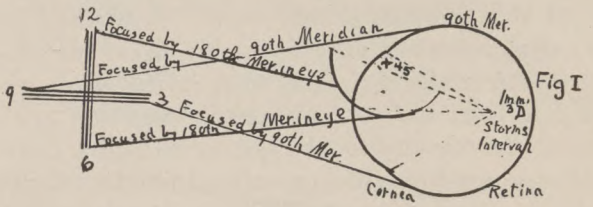


Fig I

Ans. We will first consider a case of astigmatism "with the rule." This phase means that the 90th meridian of the eye, or one nearer the 90th than the 180th, has the greatest refractive power. In the diagram about the 90th meridian of the cornea has a dioptric power of +45.00 and the 180th meridian a power of +42.00, or normal.

Without any fog on the patient the focus of the 180 meridian would be in the retina and the focus of the 90th meridian one millimeter in front of the retina. When looking at the astigmatic chart the patient would see the twelve to six spoke of the dial plainest, because this spoke is focused by the 180th meridian

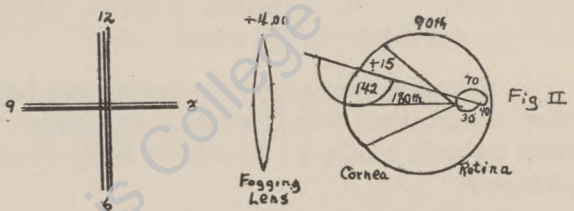


Fig II

in the eye, and since this focus is nearest the retina patient is able to see the twelve to six spoke plainest.

Now by fogging the patient with plus spheres both foci are brought in front of the retina and the patient will continue to see

the twelve to six spoke plainest at all times. Now we start reducing the fog, and find that by placing minus cylinders, axis 180 before the eye the dial appears more uniform and that a —3.00 D. cylinder axis 180 makes the astigmatic chart uniform and that any plus spheres combined with this minus cylinder blurs vision. So we finally get the prescription —3.00 D. cylinder axis 180, or transposed —3.00 D. sphere ⌒ +3.00 cylinder axis 90.

In the latter prescription the —3.00 D. sphere carries the foci of the meridians back three diopters. The focus of the 90th meridian to the retina and the focus of the 180th meridian three diopters back of the retina. Now by combining with the —3.00 D. sphere a +3.00 D. cylinder axis 90, the focus of the 180th meridian is brought forward to the retina.

In a case of mixed astigmatism with the rule, the meridian of least error would focus nearest the retina, and, supposing it to be the 180th meridian, the twelve to six spoke would appear the plainest without fogging lenses. After fogging lenses are placed before the eye and the focus of the 90th meridian is brought forward the spokes would shift and the twelve to six spoke appear black.

Always remember that the meridian of least error is nearest the retina and that the focus of that meridian is, if the 180th in the eye, the twelve to six spoke on the chart, and if the 90th meridian in the eye, the nine to three spoke on the chart.

Th interval between the focus of the two principal meridians remains the same until cylinders are used. Fogging lenses merely bring both the foci forward and until cylinders are used "Sturm's Interval" remains the same.

Presbyopia

Q. What is presbyopia?

Ans. Presbyopia is a change that occurs in the eye, resulting in the impairment of one of its functions. The term presbyopia is applied when there is a manifest inability of an eye to produce comfortable accommodation at the reading distance.

Q. Give cause of presbyopia.

Ans. Presbyopia is due to the hardening of the crystalline lens as a result of age.

Q. State the functional disturbance in presbyopia.

Ans. Due to the hardening of the crystalline lens, the harmonious and intimate relationship between accommodation and convergence is disturbed and broken up in presbyopia.

Q. Under what conditions is it necessary to prescribe bifocals for patients under 40 years of age?

Ans. When there is aphakia, the ciliary muscles paralyzed or there is a high degree of myopia or the ciliary muscles are weak or undeveloped.

Q. To what is presbyopia due?

Ans. Owing to a change in the crystalline lens, resulting in a process of gradual sclerosis, the accommodation diminishes with age, which is manifested by a gradual loss of accommodation when the near point has receded beyond nine inches.

Q. A patient's reading glass is —2.75 cyl. ax. 180 and he is presbyopic two diopters, what is the distance correction?

Ans. The patient must have myopia and presbyopia of equal amount, as the cylinder corrects the astigmatism only. Therefore, his distance correction would be —2.00 D. sph. ⌒ —2.75 D. cyl. ax. 180.

Phoria

Q. What is isophoria?

Ans. A state in which the tension of the vertical muscles of each eye is equal, and the visual axes lie in the same horizontal plane when in a state of rest.

Q. What is kataphoria?

Ans. Kataphoria is a tendency of both eyes to turn downward while in use for distant vision.

Q. What is anaphoria? Anatropia?

Ans. That condition in which the eyes have a tendency to turn upward more than the normal amount, while in use, and turn upward when the extrinsic muscles are in a state of rest. Anatropia is that condition in which the eyes turn up more than the normal amount at all times.

Q. What is cataphoria?

Ans. That condition in which one of the eyes has a tendency to turn downward below its fellow while in use.

Q. What is the difference between esophoria and esotropia?

Ans. Esophoria is a tendency of the eyes to converge excessively, but which is overcome by the stimulus to binocular single vision in the active use of the eyes. Esotropia is the actual deviation inward of the two eyes. It is generally known as converging strabismus.

Q. If hyperopia and esophoria co-exist which would you correct first and why?

Ans. Would correct hyperopia first, for it has been found by experience that in these cases, if the hyperopia is corrected, the esophoria will usually disappear.

Q. Define esophoria.

Ans. Esophoria is that condition where the eyes have a tendency to turn in, although parallel, while in use for distant vision, and actually turn inward when the extrinsic muscles are in a state of rest.

Q. What is cyclophoria? How would you detect it?

Ans. Cyclophoria is that condition where there is a tendency of the eye to rotate wheel fashion on its antero-posterior axis toward the right or left. The test is made by the double prism over one eye and a straight line 20 feet away. It can also be made by placing a Maddox rod over each eye, one vertical and the other horizontal. If the eyes are orthophoric the patient will

see a perfect cross. If cyclophoria is present the streaks will not be seen at right angles to each other, or 90 degrees apart, but will appear to slant.

Q. What is orthophoria?

Ans. That condition in which the visual axes are parallel when the extrinsic muscles are in a state of rest, perfect muscular balance or co-ordination.

Q. What is hyperphoria?

Ans. Hyperphoria is the term used to indicate a tendency of one eye to deviate above that of its fellow. This upward tendency may affect either eye; therefore, we have right hyperphoria and left hyperphoria.

Q. What is the position of the correcting prism for hyperphoria?

Ans. The position of the correcting prism is base down over the hyperphoric eye, or base up over the other eye. It may be divided between the two eyes, when more than three prism diopters are required. It is best, however, to place the prism on the non-fixing eye.

Q. What is meant by latent deviations?

Ans. By latent deviations is meant suppressed squint, latent squint or heterophoria.

Q. What phorias are indicated when the test shows the following to be present: (a) Vertical diplopia, (b) homonymous diplopia, (c) heteronymous diplopia?

Ans. Vertical diplopia indicates hyperphoria, homonymous diplopia indicates esophoria, and heteronymous diplopia indicates exophoria.

Q. If upon examination you discovered a patient was hyperopic two diopters and had esophoria of one meter angle, and three degrees of left hyperphoria and you decided to prescribe a correction to relieve the imbalance, which one of the phorias would you consider the one to correct?

Ans. Would consider the left hyperphoria the one to correct, as the correction would tend to relieve the excessive convergence and assist in placing accommodation and convergence

in harmony, as plus lenses relax accommodation, which in turn relaxes the convergence.

Q. When exophoria is associated with hypermetropia, what may be done toward correcting the former, and to what extent should the latter be corrected?

Ans. Ocular gymnastics by means of rotary prisms, base out. It is customary in cases of this kind to sometimes give a partial correction. How much is a matter of experience and judgment. Prisms may be prescribed base in for constant wear together with the full correction for the refractive error.

Q. Name that form of imbalance of the eyes in which the visual axis of the left eye has an upward tendency? Upward deviation?

Ans. Left hyperphoria. Left hypertropia.

Q. A patient is emmetropic, but has 1½ meter angles of esophoria; with the Maddox rod on the right eye, the vertical streak of light is seen 18 cm. to the left of light, while a certain prism is in place before the left eye, testing at 6 meters. What is the power of the prism? Give position of its base.

Ans. Twelve degree prism. Base out, on the left eye. One and one-half meter angles equal 9$^{\Delta}$ of esphoria, testing at 6 meters; every 6 cm. equals 1$^{\Delta}$; therefore, 18 cm. equals 3$^{\Delta}$ of artificial exophoria. The prism in place must be a 12$^{\Delta}$, as it over corrects the esophoria by 3$^{\Delta}$.

Q. If there is a tendency of the visual axes of the eyes to diverge, or when the deviation actually exists, what are these conditions called?

Ans. A tendency to deviate from normal is heterophoria exophoria, and actual deviation is heterotropia exotropia. Strabismus or diverging squint.

Q. Name that form of imbalance of the eyes in which the visual axis of the right eye has an upward tendency.

Ans. This form of muscular imbalance is called right hyperphoria.

Q. In what way may phorias and tropias be corrected?

Ans. By prism exercise placing the apex of the prism over the muscle you wish to exercise or over the weak muscle, this can be best accomplished by means of rotary prisms. The strain may also be relieved by the correction of the refractive errors present by decentering the lenses, or by prisms, either alone or in combination with the correcting lenses.

Q. Name and describe eight heterophorias.

Ans. Exophoria: Eyes have a tendency to turn out. Esophoria: Eyes having a tendency to turn in. Right hyperphoria: Right eye has a tendency to turn up above its fellow. Left hyperphoria: Left eye has a tendency to turn up above its fellow. Right hyperexophoria: Right eye has a tendency to turn up and out. Right hyperesophoria: Right eye has a tendency to turn up and in. Left hyperexophoria: Left eye has a tendency to turn up and out. Left hyperesophoria: Left eye has a tendency to turn up and in.

Q. What is heterophoria?

Ans. Heterophoria is a tendency of the visual axes of the eyes to deviate from their normal, yet are held from actual deviation by the excessive action of the extrinsic muscles.

Q. Name two terms applied to heterotropia.

Ans. Manifest squint and strabismus.

Q. What is the difference between muscular insufficiencies and accommodation?

Ans. Muscular insufficiencies are due to inability of the muscles to normally functionate. Accommodation is the power of the eye to adjust its refraction.

Q. In the measurement of muscular imbalances, what is the first thing necessary to do?

Ans. With the distance correction in place, destroy all desire for fusion, or single binocular vision, by the use of the Maddox rod or double prism.

Q. Name an objective heterophoria test?

Ans. The cover test is an objective test in which the ob-

server sees the eye turn as the cover is removed and put back in place.

Q. How are the external and internal muscles tested?

Ans. The external muscles are tested by applying prisms base in, of increasing power until the patient looking at a light sees the light double. The highest power with which he can keep the light single is the measure of power of his externi. To test the interni, we put the base of the prisms out and proceed the same way.

Q. Under what condition do the extrinsic muscles act in harmony?

Ans. In orthophoria or normal conditions the action of the extrinsic muscles is at all times harmonious and reciprocal.

Strabismus

Q. What is strabismus?

Ans. Strabismus is a deviation of the visual axes of the two eyes so that these do not intersect in the object of regard.

Q. Name the varieties of strabismus.

Ans. Convergent, divergent, vertical, monolateral, alternating, periodic, concomitant and paralytic.

Q. What error of refraction is liable to produce strabismus? Why?

Ans. Faculative hypermetropia. When the relation between accommodation and convergence is strong and the error is one of hyperopia there may be overaction of the convergence, due to overaction of the accommodation. Convergent strabismus is the result.

Q. Why does strabismus cause amblyopia?

Ans. Strabismus may cause amblyopia because only one eye can be used for direct vision, which is usually the best eye. The poor eye, being ignored for direct vision, gradually gives up the function of seeing.

Q. Name the causes of convergent strabismus.

Ans. Anisometropia, short internal muscles, paralyzed ex-

ternal muscles and excessive accommodation. Faculative hypermetropia is a common cause.

Q. Name the three clinical varieties of convergent concomitant strabismus.

Ans. Periodic, permanent alternating and permanent monolateral.

Q. What do you understand by primary and secondary deviation in strabismus?

Ans. In concomitant squint the defective or squinting eye remains in the primary position or deviation. If the straight or fixing eye be covered the squinting eye is obliged to fix the object in regard. It will be found that the straight eye under cover will squint. This deviation is called secondary, and is equal in degrees to the primary deviation.

Q. What are the two most usual causes of strabismus in children and how corrected?

Ans. The two common causes are hyperopia and weak muscles. Where it is the former, the eyes can usually be straightened by plus lenses, provided vision is fair in both eyes, or can be made so. When due to weak muscles a course of ocular gymnastics should be given.

Q. Would a hyperope of 2.50 D. or one of 5.00 D. be most liable to develop convergent strabismus?

Ans. A hyperope of 2.50 D. forces his ciliary muscles constantly into action with a strong possibility of developing convergent strabismus, as a result of the excessive convergence stimulated due to the relation between accommodation and convergence, but a person with 5 D. of hyperopia finds it so difficult to use his eyes with exactness that he gives up the attempt.

Q. What is the difference between concomitant and alternating squint?

Ans. Alternating squint is a form of concomitant squint in which the patient sometimes squints with one eye and sometimes with the other eye; both eyes are affected equally.

Q. Name the forms of strabismus which will not yield to ocular gymnastics.

Ans. Paralytic strabismus. Congenital strabismus after twenty years' standing. Strabismus associated with marked amblyopia, or any form of strabismus having been previously operated. Also strabismus in a child under five years of age.

Q. What do you understand by the angle of strabismus?

Ans. The angle of strabismus may be defined as the angle which the visual axis makes with the direction it should have in a normal state.

Q. What is the difference between concomitant and paralytic strabismus?

Ans. In concomitant strabismus the deviating eye maintains the same relation with the fixing eye and follows its movements. In paralytic strabismus the squinting eye is unable to follow in the direction of the paralyzed muscle.

Q. What is concomitant squint?

Ans. That condition where the two eyes deviate but accompany one another in their movements. The object can be seen by either eye, but not by both eyes at the same time.

Chapter VII

PRACTICAL OPTOMETRY

Q. Define optometry.

Ans. Optometry is the science of measuring and correcting the refractive errors and muscular anomalies of the human eye by means other than drugs, medicine, or surgery.

Q. Which is most important to know, when to prescribe or when not to prescribe, in the practice of optometry?

Ans. It is equally important to know when to prescribe and when not to prescribe, and the scientific practitioner who knows when to prescribe also knows when not to prescribe.

Q. Under what conditions would you advise the patient not to wear glasses?

Ans. When a careful examination reveals the fact that glasses are not indicated and will in no way benefit the patient. The conscientious practitioner will not prescribe, in cases of this kind, and in case the patient is wearing glasses, he should be informed of the fact that glasses are of no benefit. Should diseased conditions be present the patient should be advised to consult an oculist or physician, as the case may require.

Q. What advice would you give to a patient who complains that the eyes feel tired and uncomfortable in the morning?

Ans. The eyes may be normal, but overworked. If the refractive error is corrected, advise the patient to wear glasses constantly and rest the eyes as much as possible.

Q. What are convex spherical lenses sometimes prescribed, that exceed in strength the manifest hyperopia?

Ans. The purpose is to correct the latent hyperopia present, relieve strain and relax excessive convergence in esophoria or esotropia.

Q. A patient 60 years of age can no longer see with plus lenses, which were formerly satisfactory for distance. The test shows a minus correction. What condition would you suspect?

Ans. Swelling of the crystalline lens, thus increasing the refraction of the eye. This condition is usually a forerunner of a senile cataract.

Q. After fogging a patient with plus lenses, and when bringing him out of the fog, by reducing the plus, when do you stop if there is no astigmatism?

Ans. Leave on the strongest plus. If the patient is hyperopic, that gives the best vision at six meters or 20 feet. If myopic, give weakest minus that gives normal vision at 20 feet.

Q. When is an undercorrection best?

Ans. An undercorrection is best when it gives comfortable vision and a full correction does not, as in high errors of refraction.

Q. How would you determine whether a person was blind in one eye or was malingering?

Ans. This can be determined by several tests. One of the most satisfactory consists in covering the eye supposed to be blind and placing an 8^ prism before the other eye, so that its base will cross the center of the pupil, apex up. This effect induces monocular diplopia. The blinder is removed quickly and the prism shifted down. This will produce binocular diplopia, if the patient has binocular vision.

Q. Mention the various methods you would employ in making a complete and thorough examination of the eyes for glasses?

Ans. After receiving and seating the patient in an appropriate manner, I would get the following general information, before starting in the actual examination: Patient's full name, address (including telephone number), occupation, and history of the case in detail. The questions asked should bear directly upon the eyes, such as information relating to any recent illness, etc. The first step in the examination proper is the acuteness of vision. First with both eyes, then with each eye separately.

Next, the ophthalmoscope may be employed to determine the transparency of the media and the healthfulness of the interior of the eye. The lids, cornea conjunctiva and other external appendages should also be examined. Next, use the retinoscope to determine the presence and measure of any refractive error. If astigmatism is present, the ophthalmometer may be used at this time. Then, the trial case test is made to prove up the retinoscopic findings, using the fogging method. If vision is not normal or better, the pin hole disc should be used. Next, the Maddox rod may be used in testing for muscular imbalances (heterophoria). The test is made at six meters and should also be made at the reading distance. This is an important test, as it has direct bearing on the lenses we prescribe. In myopia with exophoria we would give full correction or nearly so. In hyperopia with esophoria we are justified in crowding the plus, giving stronger lenses. Whereas under reverse conditions we might find it necessary to reduce the strength of the lenses, give the patient ocular gymnastics or prescribe prisms. Next we make the duction test by means of rotary prisms. Now with the distance correction still in place we test the amplitude of accommodation by finding the nearest point the patient can read fine print. This distance, in inches, divided into 40, gives amplitude of accommodation in diopters. If unable to read fine print at 9 inches, or nearer, presbyopia is present and enough plus power must be added to give comfortable vision at the desired distance. Next the color test may be made with samples of different colored yarns. Now the P.D. is taken, together with other frame measurements, mounting or frame selected, size, form and shape of lenses determined, time set for the patient to call for glasses and price on glasses, etc., fixed, a liberal deposit should be made by patient. Next, dismiss the patient.

Q. Mention a test that may be employed to prove the distance correction.

Ans. Place a pair of +2.50 D. spheres in position over the distance correction. If this does not blur the test letters at 20 feet completely, the patient is undercorrected, if hyperopic, and overcorrected, if myopic.

Q. Name the seven regular correctible errors of refraction and write Rx. for each.

Ans. Hyperopia Rx. +2.00 D. sph.

Myopia Rx. —3.00 D. sph.

Simple hyperopic astigmatism Rx. +1.00 cyl. ax. 90.

Simple myopic astigmatism Rx. —1.50 cyl. ax. 180.

Compound hyperopic astigmatism Rx. +1.00 sph. ⊃+1.50 cyl. ax. 90.

Compound myopic astigmatism Rx. —2.00 sph. ⊃—1.00 cyl. ax. 180.

Mixed astigmatism Rx. +1.50 sph. ⊃2.50 cyl. ax. 180.

Q. A patient comes to you for examination having never worn glasses. You find him hyperopic 2.50 D. He also had 8 degrees of esophoria. What would you prescribe?

Ans. His full distance correction, and depend upon establishing the normal relation between accommodation and convergence.

Q. Why is it necessary to change reading glasses for patients over 42 years of age?

Ans. It is necessary to change the glasses as presbyopia constantly increases between the ages of 42 and 70 years.

Q. If the patient is presbyopic one diopter, yet reads perfectly without glasses, what is his error of refraction and distance correction?

Ans. Myope of 1.00 D. distance Rx. minus 1.00 D. sphere.

Q. What would be the effect if a pair of correcting lenses, one of which was +4.50 D. and the other +5.00 D., is set 3 mm. closer to the eye than the position of the correcting lenses, as used in testing with trial case?

Ans. It would decrease the effective power of the lenses and make objects appear farther away.

Q. What is the proper reading correction for a hyperope of 1.25 D., age 53 years?

Ans. The average amplitude of accommodation at the age stated is about 2.00 D. Assuming the reading distance to be 33⅓ cm. and allowing the patient to use half of his accommodation, it

would require 2.00 D. of plus added to the distance correction, which would make a total reading of plus 3.25 D.

Q. In prescribing lenses for presbyopes, at which point would you leave the positive refracting power of the eye?

Ans. At the near point of refraction.

Q. In what kind of refractive errors and why is the fogging method of great value?

Ans. The fogging method is of the most value in hyperopic errors, accompanied by an active accommodation, as it tends to relax the accommodation.

Q. In a patient, age 23 years, with two diopters of hypermetropia the pin hole disc makes the letters on the chart 20 feet away look less distinct than with the naked eye, while in a myope of the same amount the pinhole disc shows a marked improvement. What is the reason?

Ans. This would indicate that the hypermetropia is facultative, and the patient is accommodating for the error. Therefore, the pinhole disc will not improve, but tend to make vision worse. In the myopic patient the disc will show a marked improvement, as the pinhole disc shuts out all peripheral light and allows only a small cone of light to enter the eye, thereby reducing diffusion.

Q. What effect would it have to set the correcting lenses which were —6.50 D. in one eye and —7.00 D. in the other eye 3 mm. farther from the eyes than was the position of the correcting lenses, as found with the trial case examination?

Ans. It would decrease the effective power of the lenses and make objects appear smaller and farther away.

Q. In which direction do rays of light emerge from myopic eyes, and how could they be made parallel?

Ans. Rays of light coming from a myopic eye will be converging and a minus lens of proper strength will make them parallel.

Q. At what distance should a plus 8.00 D. sphere be placed from the eye in order to give a myope of 3.00 D. normal vision for distance?

Ans. At 18 inches from the eye. A plus 8.00 D. sphere has

its principal focus at five inches. Then the rays will cross, diverge and become minus. When they have traveled 13 inches they would be a minus 3 D. wave, which would neutralize the 3 D. of myopia.

Q. Why do plus and minus lenses change the size of the retinal image?

Ans. The size of the image is modified. Thus plus lenses bring forward the nodal point and so increase the size of the image, while minus lenses carry the nodal point backward and so diminish the size of the image.

Q. What tool curves should be used to grind a plus 6 D. base curve, toric, on the following Rx.: +.50 sph. ⌒ —1.50 cyl. ax. 180?

Ans. First, we would transpose the prescription, then put it up on a +6.00 D. B.C., which would give a surface power of +6.00 D. in the 90th meridian and +7.50 in the 180th meridian. On the concave side the surface power would be —7.00 D. Therefore the tool curve used in the 90th meridian must be —6.00, in the 180th meridian —7.50, and on the concave side +7.00, as a plus tool curve impresses minus and a minus tool curve impresses plus.

Q. How much sphere is there in the following correction: +4.00 D. sph. ⌒ —3.50 cyl. ax. 180; and what error of refraction would it correct?

Ans. Plus .50 sphere. It will correct compound hyperopic astigmatism with the rule.

Q. A child 11 years of age has 3.00 D. of hypermetropia and an apparent esophoria of 6°. No glasses have been worn. Will the correction of the hypermetropia tend to increase or decrease the apparent esophoria?

Ans. The plus correction will relax accommodation and convergence. Therefore it will tend to decrease the esophoria.

Q. A patient wearing a plus 2.00 D. sph. has the P.R. at 16 inches and the P.P. at 8 inches. What is his age, error of refraction, amplitude, distant Rx. and reading Rx., allowing the patient

to use half of his accommodation? How much accommodation would there be in reserve while viewing an object 18 inches from the eye while wearing the reading Rx.?

Ans. 50 years. Error myopia, amplitude 2.50 D., distance Rx. —.50 sph., reading Rx. +1.25 sph., reserve accommodation at 18 inches 2.00 diopters.

Q. What advice would you give a patient when starting out with the first pair of glasses?

Ans. Sometimes something very much like car sickness occurs during the first several days of wearing the full correction. This is common when cylinders with oblique axes are worn. Patients should be told in advance of the probabilities, but be assured that if they wear the correction for a week or two they will be pleased with the results. It is merely a temporary disturbance of the nervous system while it is adjusting itself to the normal conditions.

Q. When a pair of spectacles is placed on the patient it is observed that the right lens is higher than the left. Without reference to the proper height of the glasses, state what temple adjustment will level the lenses?

Ans. It is necessary to cause the right lens to come down lower. To accomplish this the temple must be bent up so when placed into position on the ear the lens will go down with it, or raise the left lens by bending the temple down.

Q. Under what conditions would you consider it advisable to recommend two pairs of glasses, even though the formula remains the same?

Ans. When one lens is much stronger than the other. In reading the wearer looks down eight or ten millimeters below the optical centers and would get stronger prism effect on one eye, creating an artificial hyperphoria. Advise an extra pair for close vision only, centered properly. In very high degrees of myopia and hyperopia it is well to recommend two pairs, each centered properly, and the reading pair made pantiscopic.

Q. What is the difference between presbyopia and errors of refraction?

Ans. Errors of refraction are due to curvatures of the refractive surfaces of the ocular media. Presbyopia is due to the hardening of the crystalline lens as a result of age, and is not an error of refraction.

Q. In testing with the stenopaic disc it is found that the O.D. requires +2.50 D. in the vertical meridian and —.50 D. in the horizontal. O.S. requires +1.75 D. in the vertical and +.50 D. in the horizontal meridian. What is the corresponding prescription?

Ans. O.D. —.50 sph. ⊃ +3.00 cyl. ax. 180 or +2.50 sph. ⊃ —3.00 cyl. ax. 90. O.S. +1.75 sph. ⊃ —1.25 cyl. ax. 90 or +.50 sph. ⊃ +1.25 cyl. ax. 180. Cross cylinders O.D. +2.50 cyl. ax. 180 ⊃ —.50 cyl. ax. 90. O.S. +1.75 cyl. ax. 180 ⊃ +.50 cyl. ax. 90.

Q. What refractive error is produced by conical cornea?

Ans. Myopia.

Q. If a child eleven years of age, in good health, shows under the objective test, with the retinoscope, 5.00 D. of hypermetropia and with the Maddox rod shows 7° of esophoria, and after having the correction before the eyes fifteen minutes, looking through them sees twenty-twenty, and with a +4.50 the patient reads twenty-fifteen, what would you prescribe? Decenter lenses in or out?

Ans. Would prescribe the +5.00 D. sphere and would not order the lenses decentered, as the correction tends to put accommodation and convergence in harmony.

Q. Looking at an object 3 meters distant, how much would an object seem to be displaced if a 5.00 D. prism is placed before the eye?

Ans. A 1.00 D. prism would seem to displace an object 1 cm. in one meter distance or 3 cm. in 3 meters distance; therefore, 5.00 diopter prism would seem to displace an object 5 cm. in one meter distance, or 15 cm. in 3 meters distance.

Q. What would be the magnifying power of a field glass, with a 30 D. eyepiece and +6.00 D. objective?

Ans. To find the power of a field glass, we divide the dioptric power of the eyepiece by the dioptric power of the objective. Thus 30÷6=5 times.

Q. Mention five methods of estimating errors of refraction.

Ans. By means of retinoscope, ophthalmoscope, direct method, trial case, fogging method, cobalt test and ophthalmometer.

Q. Describe the chromatic disc and of what is it composed?

Ans. The chromatic disc (or cobalt disc) consists of a piece of glass colored by presence of the mineral cobalt. The glass appears blue by transmitted light, but in reality it allows blue and red rays to pass, and cuts out the central part of the spectrum.

Q. What deformity of the eye often results from excessive near work?

Ans. Excessive near work may cause squint, myopia and spasm of the accommodation.

Q. What is the amplitude of accommodation of a hyperope of three diopters whose near point is at twenty-five centimeters?

Ans. Twenty-five centimeters or ten inches corresponds to four diopters, but, as he is a hyperopic three diopters, his amplitude of accommodation must be seven diopters.

Q. Give the rule by which the meter angle may be expressed in prism dioptries for any given interpupillary distance.

Ans. The meter angle contains as many prism dioptries as there are centimeters in an individual's interpupillary distance. Example: P.D. 64 mm. = 6.4 cm. ÷ 2 = 3.2 cm.; therefore, every meter angle in the above has a value of 3.2 prism diopters for each eye and 6.4 prism diopters for the two eyes. There are normally nine such meter angles in the eye; therefore, the total number of prism dioptries is $9 \times 3.2^{\Delta} = 28.8^{\Delta}$ for each eye.

Q. What is the prism dioptric value of the meter angle of a subject whose interpupillary distance is 58 mm.?

Ans. 58 mm. = 5.8 cm. ÷ 2 = 2.9^{Δ}. Hence the meter angle in this case equals 2.9 prism dioptries for each eye or 5.8 prism dioptries for the two eyes.

Q. What is the meter angle and upon what does its size depend?

Ans. The meter angle is the amount that the eyes turn inward from parallelism when viewing an object at one meter away. The size of the meter angle depends upon the pupillary distance.

Q. Find size of the meter angle for a person whose P.D. is 64 mm., expressed in degrees.

Ans. The meter angle, being the angle formed by the visual axes when the eyes are converged to a point at one meter, we first find the circumference of a circle whose radius equals 1 meter.

R. = 1 m. or 1000 mm.

Diam. = 2 m. or 2000 mm.

2000×3.1416=62832.2 mm. circumference.

Now, taking the given P.D. as an arc of this circle, we find the angle subtended by this arc at the center. The circle contains 360 degrees. Then the arc formed by a one degree angle equals 6283.2÷360=17.45+ mm.

64÷17.45=3.66 degrees.

The meter angle of convergence, if we consider each eye singly, is that angle formed by the visual axis and the meridian line when the eyes are fixed at a point 1 meter distant. Hence the meter angle for each eye in the above case would be ½ of 3.66° = 1.83°.

Q. What is the interpupillary distance of a subject whose meter angle is 1° 45′ for each eye?

Ans. The diameter for a circle with a radius of 40″ equals 80″ or 2000 mm. multiplied by 3.1416 gives the circumference 6283.2 mm. divided by 360, the number of degrees in the circle, equals 17.4533 mm. for one degree, then 3½°×17.4533+=61.0865 mm. P.D.

Q. What is the interpupillary distance of a subject whose meter angle is 1° 48′ for each eye?

Ans. The meter angle for the two eyes would be 3 3/5°× 17.4533=62.83 mm. P.D.

Q. How would you measure a patient's pupillary distance for distant vision?

Ans. For distant vision the refractionist should stand back an arm's length, place rule in position before patient's eyes, patient looking over the refractionist's head at infinity. The refractionist should sight patient's right eye with his left eye, closing right eye. Then patient's left eye, with the refractionist's right eye, closing left eye. Then measure from outside of one iris to inside of other.

Q. How would you measure patient's pupillary distance for reading?

Ans. For reading the refractionist should stand at the desired distance for reading and do all the sighting with one eye, while the patient is converging for that distance.

Q. What is the general rule to follow in taking the pupillary distance in hyperopes? In myopes?

Ans. Pupillary distance for hyperopes should be from one to two millimeters shorter than the actual measurement to insure comfort. Myopes may wear full-length pupillary distance or even a little more, but never less than full length, providing the patient is orthophoric.

Q. In optometry, what is implied by infinite and finite distance?

Ans. The meaning of infinite distance in optometry is a distance so great that light, traveling from such a distance, would be considered as parallel. All distances inside of 20 feet are finite distances. In the practice of optometry 20 feet is considered as equivalent to infinity.

Q. Name three properties of Canadian balsam with respect to its use in optometry.

Ans. Canadian balsam hardens after the application of heat, is adhesive, and has practically the same index of refraction as that of crown glass.

Q. What is a good formula for a solution to clean lenses?

Ans. A mixture of water, denatured alcohol, turpentine and perfumed ammonia.

Q. The wearer of a pair of spectacles complains that the lashes sweep the left lens, while the lashes escape the right lens by a considerable margin. What temple adjustment is necessary?

Ans. The temple for the left lens must be uncurled at the end so as to lengthen it. The right temple should be curled slightly to draw the right lens back.

Q. What is meant by objective and subjective testing?

Ans. An objective test is one in which the operator sees conditions, as in retinoscopy. A subjective test is one in which the operator relies on what the patient tells, as in trial case examination.

Q. A certain patient is astigmatic, presbyopic and hypermetropic. In what order are these defects tested for and corrected?

Ans. Usually the astigmatism is corrected first, then the hypermetropia and lastly the presbyopia.

Q. State the average punctum proximum of an emmetropic eye in a person 40 years of age?

Ans. The amplitude of accommodation at the age of 40 years should be 4.50 D. This would bring the P.P. into about 9 inches.

Q. What is the principal focal distance of a lens, bi-convex, having radii 8 and 5 cm. and an index of 1.54?

Ans. Apply rule and get the meter curves. Then multiply the M.C. by the difference of index, which equals the power. Then divide the unit by power of the focus.

(Reduce the unit 40 to cm.)

100÷5=20 M.C.+
100÷8=12.5 M.C.+
Total...32.5 M.C.+

32.5 M.C. × .54 excess index = +17.55 power.
100÷17.55=5.698 cm. focal distance.

Q. If a patient 22 years of age sees distinctly at all distances, but complains of headaches and eye strain, especially at close work, what condition would you suspect?

Ans. Hypermetropia, astigmatism, exophoria or weak internal muscles, or a combination of several, or all.

Q. Distance Rx. of right eye missing.
Rx. O.S. +1.50 sph. ⌒ +1.25 cyl. ax. 90.
Reading Rx. O.D. +2.50 sph. ⌒ —.75 cyl. ax. 180.
Reading Rx. O.S. +4.50 sph. ⌒ —1.25 cyl. ax. 180.
What is the distance Rx. for O.D.?

Ans. Assuming that the same amount was added to each lens for reading, the missing Rx. for the O.D. would be + 75 sph. ⌒ —.75 cyl. ax. 180. Transposed: +.75 cyl. ax. 90.

Q. A hyperope of three diopters is just able to read fine print at 13⅓ inches without lenses. How much accommodation has he and what will his P.P. be with glasses?

Ans. Just able to see to read at 13⅓ inches without glasses, he must use three diopters of accommodation for that distance, and also three diopters to correct his hyperopia, so in all he would use 6.00 D., which would equal his amplitude of accommodation. With his correction on, his near point would be 40÷6=6.66 inches.

Q. Explain why the refraction of the eye changes and the findings differ slightly when examined at different intervals by the same methods and under like conditions?

Ans. This may be due to two reasons: First, the continual change in the aqueous humor, which changes completely every twenty-four hours and under certain systemic conditions may vary slightly in density. Second, the atmospheric changes affect vision, as warm air is less dense than cold air; therefore, changes the relative density between air and the cornea. This change is noticeable when visual acuity is normal or better; therefore, affects the findings slightly.

Q. What is an amblyoscope and for what is it used?

Ans. An amblyoscope is a special form of stereoscope in which the two sides of the instrument are hinged together so they may be set at any angle to each other. The instrument is used in developing the fusion sense in eyes that have weak or poor

fusion due to an error of refraction, amblyopia or some other cause.

Q. What is the perimeter?

Ans. The perimeter is an instrument for measuring the field of vision.

Q. What is Holmgren's test?

Ans. A set of colored skeins of yarn are used for the detection of color blindness.

Q. What is meant by oblique illumination?

Ans. A method of reflecting light obliquely upon the cornea. This method is used in examination of the cornea for opacities, scars, etc. It is also employed to ascertain the progress of cataract development.

Q. Of what use is the pinhole test?

Ans. In cases where the visual acuity of the eye is low the pinhole test will often decide whether the low vision is due to refractive error or to amblyopia.

Q. What is indicated when the pinhole alone produces marked improvement of vision?

Ans. If the pinhole disc alone improves vision the refracting surfaces are at fault. When the pinhole alone and nothing else produces a marked improvement of vision, the case is one of marked irregular astigmatism.

Q. Of what use is the stenopaic slit?

Ans. This is the most useful instrument in certain cases of astigmatism of high degrees. Simple mixed and compound. When the error of the one principal meridian is large compared with that of the other. The stenopaic slit is used to locate the principal meridians in an astigmatic eye. The amount may also be determined by employing spherical lenses from the trial case. By means of the astigmatic dial this is difficult owing to the low degree of vision. It is in such cases that the stenopaic slit proves useful.

Q. What is the principal of the pinhole disc?

Ans. In vision through a pinhole, if visual acuity is low because of a refractive error that cannot be corrected by the ac-

commodation the areas of diffusion in the image are decreased as the pinhole disc allows passage to a small pencil of light, which passes through the center of the refracting media of the eye. If vision is improved by the pinhole the refracting media is at fault. Lenses should give the same vision as the pinhole gives except in cases of irregular astigmatism.

Q. How should the lenses of a stereoscope be mounted with regard to the base of the prisms?

Ans. They should be mounted bases out, so that the visual axes of the two eyes looking through them meet in the plane of the two stereoscopic views. They should coincide at the object of regard.

Q. Are the eyepieces of an opera glass negative or positive?

Ans. The eyepieces of an opera glass are negative.

Q. If a patient 28 years of age requires minus 1.00 D. sph. to give him 20/20 vision and yet has marked symptoms of presbyopia, what would you suspect?

Ans. Would suspect spasm of the accommodation accompanied by latent hypermetropia. The patient is under the influence of a cycloplegic or has premature presbyopia. This condition may also be due to paresis of the ciliary muscles.

Q. What is the correct Rx. for distance for a patient age 25 years looking at 13 inches with his focus in the retina while wearing a +2.00 D. sph. ⊂ —3.00 cyl. ax. 90 and using 2.00 D. of accommodation?

Ans. It requires 3.00 D. to read at 13 inches. The patient is wearing +2.00 D. sph. and accommodating 2.00 D., which equals 4.00 D. This is 1.00 D. more than an emmetrope would use; therefore, the patient must be hyperopic 1.00 D. because he uses 1.00 D. more than the normal amount. So we combine the +1.00 D. sph. with the —3.00 cyl. ax. 90, which would be his distance correction.

Q. Under what circumstances would an ametrope age 20 years need reading glasses in addition to his distance correction?

Ans. Where there is paralysis of the cilliary muscles,

aphakia, or undeveloped cilliary muscles, as in high degrees of myopia.

Q. What do you consider the most essential measurement in fitting a spectacle or eyeglass mounting?

Ans. The P. D. is usually considered the most important, though other measurements, if taken wrongly, cause much annoyance.

Q. A patient with a P.D. of 59 mm. wears O.U. +4.00 sph. for distance. The glasses have a P.D. of 62 mm. What is the prismatic effect and amount worn?

Ans. The decentration is 3 mm. out, which would give a prismatic effect of 1.20 D. prism base out.

Q. What error of refraction may be present and the patient still have 20/15 vision?

Ans. As normal visual acuity, in some cases, is 20/10, any variety of ocular refraction may be present when vision is 20/15. Usually such cases are facultative hypermetropes.

Q. A presbyope 60 years of age, requiring plus two diopters for reading at 16 inches, wishes glasses to shave with. He wishes to be able to see perfectly at 10 inches from a plane mirror. What strength of lens would you prescribe?

Ans. Plus 1.50 D. sphere.

Q. Describe how you would correct a case of presbyopia which has for distance correction +1.50 sph. ⊂ +.50 cyl. ax. 90 degrees?

Ans. By adding plus sphere, strong enough to enable the patient to read fine print with comfort at the distance he wishes to read.

Q. What correction would be most likely to benefit a child having convergent strabismus?

Ans. For a child with convergent strabismus, if this is due to a hypermetropic error, the best correction is a full, or slightly over correction of the error, as this tends to bring convergence and accommodation in harmony.

Q. The patient is directed to look at a light, 6 meters away, through a 6 D. prism, base down, before the left eye. If the

upper light is seen to the right of the lower light, what heterophoric condition is present?

Ans. The lights are crossed, for the left eye sees the upper light to the right side. Being cross diplopia, indicating exophoria.

Q. If a patient 25 years of age requires +1.75 D. sphere for distance and +1.00 D. sphere added for reading, would the distance correction be wrong?

Ans. Would suspect the patient to be undercorrected for distance, as true presbyopia could not exist at that age, but could not tell except by examination of the ciliary muscles. It could be due to a diseased condition or wrong nerve impulse, which would be a case of premature presbyopia.

Q. A person seated at 20 feet reads the letters marked 20, at 80 feet distance reads the letters marked 80. What is the difference in the size of the visual angles?

Ans. The visual angle, formed on the retina as in case mentioned, will be the same size. A line drawn from the extremities of each enters the eye at the same angle. An angle of 5 minutes theoretically drawn straight forward from the retina, crossing at the nodal point, and extending forward for any distance. All objects or letters with extremities just within these lines, at all distances, will produce the same sized angle on the retina.

Q. At what distance could two +4.00 D. spheres be placed apart so that their combined effect would produce a plus 12.00 D. wave value?

Ans. Five inches apart, as the wave would enter the second lens 5 inches from its focal point, and would be a plus 8.00 D. wave value, entering the +8.00 D. lens. This wave would emerge as a plus 12.00 dioptric value.

Q. A patient who is presbyopic 1.50 diopters reads at 16 inches without lenses. What is the refractice error?

Ans. Myopic, 1.00 diopter.

Q. An object illuminated, 12 cm. square, when viewed

binocularly at a distance of 6 meters, is seen as two squares, one above the other exactly 3 cm. apart. State the nature of visual anomally, and give its approximate amount expressed in prism diopters.

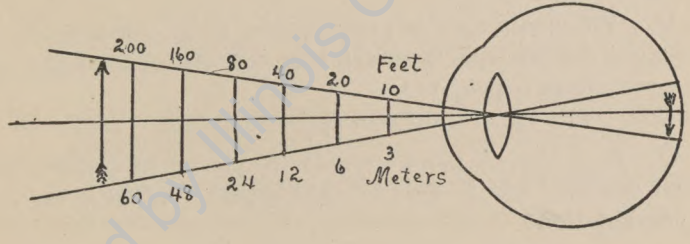
Ans. The case is one of vertical diplopia to the extent of 2½ prism diopters.

Q. Looking 3 mm. outside the optical center of a plus 8.00 D. lens, how far will an object at 6 meters distance appear displaced?

Ans. Looking 3 mm. outside the optical center would produce the effect of 2.4$^{\Delta}$, base in. As one prism diopter will deviate light 1 cm. in one meter distance or 6 cm. in 6 meters distance, 2.4 base in would appear to displace an object at 6 meters distance, outward 14.4 cm.

Q. Show the proportions of the letters in Dr. Snellen's test-chart?

Ans. The patient being seated at 10, 20, 40, 80, 160 or 200 feet from it, should read the type corresponding to the distance, as marked on the card. The usual working distance is 6 meters or 20 feet. Visual acuteness is expressed in fractions, the numerator being the distance, and the denominator the number of the type patient reads. Thus if seated at 20 feet and number 30 type is the smallest that can be read without error, vision would be recorded 20/30. If number 20 is read it would be 20/20, which equals normal vision. If number 15 is read it would be recorded 20/15.



Q. Explain the difference between the Snellen and Jaeger test types for near vision testing?

Ans. Snellen's are arranged on the same order as his distance test card, each size of letter subtending a visual angle of five minutes at given distance. Each series of letters is marked with the distance it should be read, ranging from 25 to 200 cm. Jaeger's near types are not arranged on a definite scale, but are simply letters of various sizes, ranging from very small to letters as large as used in newspaper headings.

Q. Upon what optical principle is the use of the Maddox rod based?

Ans. The Maddox rod is an opaque disc with a slit through the center. Over this slit is placed a cylinder. In looking through this rod at a small round light it causes the light to appear like a long streak. If the rod is white the red glass should be placed before the other eye. This gives the appearance of two retinal images so different that the brain does not recognize them as the same object. The eyes abandon the attempt to effect fusion, therefore rotate to their position of rest. The position which the streak assumes in relation to the light will indicate either orthophoria or heterophoria, while the eyes are under the influence of toricity only, accommodation and fusion being eliminated.

Q. How are the meridians of the eye and astigmatic dial numbered?

Ans. The meridians of the eye are numbered from right to left. The meridians of the astigmatic dial are numbered from left to right, so when they face each other the numbers correspond.

Q. When diplopia is produced by means of a prism, base up, before the left eye, in which side will the upper light appear when exophoria is present?

Ans. The upper light will appear on the left side.

Q. A +1.50 D. plano-cylinder is placed in contact with a similar one of +2.25 D. axis at right angles. What is the resultant combination?

Ans. This combination would be equivalent to a +1.50 D. sph. ⊂ +.75 D. cyl. Transposed: +2.25 D. sph. ⊂ —.75 D. cyl. In cross cylinders would be +1.50 D. cyl. ⊂ +2.25 D. cyl. any axis placed at right angles to each other.

Q. A myope of 6 D. has 3 D. of accommodation. He wants a pair of glasses to read music at 18 inches. What should be the power of these lenses in order that he must use half of his accommodation?

Ans. It requires 2.25 D. to read at 18 inches. Half of his amplitude would be 1.50 D., so it will be necessary to undercorrect his myopia. The difference between 2.25 D. and 1.50 D., would be .75 D., so the power of his glasses would be minus 5.25 sphere.

Q. If there is a tendency of the eyes to cross, on which side will the light streak appear with the Maddox rod over the left eye?

Ans. By tendency of the eyes to cross we understand a tendency toward convergent strabismus. This would result in homonymous diplopia, in which the right image belongs to the right eye and the left image to the left eye. With Maddox rod over left eye the streak of light would appear to the left. This is corrected by a prism placed base out, because prisms displace objects toward their apex.

Q. What position should be given to the prism placed before the right eye with Maddox rod before the left (the eyes being normal) so as to deflect the observed light 15 cm. to the left at 6 meters distance? What would be the strength of the prism?

Ans. The position of the prism would be base out, and it would take $2\frac{1}{2}^{\Delta}$ diopter to deflect light 15 cm. in 6 meters distance.

Q. What relation has the punctum proximum to the degree of ametropia?

Ans. Only the general relation that it is nearest the eye in myopia and farthest away in hypermetropia.

Q. Explain how ametropia may cause anomalies of the extrinsic muscles.

Ans. Facultative hyperopia may cause esophoria, because accommodation stimulates convergence. It is often responsible for esotropia in children, especially when the error is high. This happens because such a large amount of convergence is stimulated that the external muscles finally give up the effort to hold the eyes parallel, and the overdeveloped internal muscles pull the eyes in. Myopia may cause exophoria on account of the lack of accommodation, and therefore little convergence is stimulated. They see best at infinity and up to the far point with accommodation at rest. A high refractive error in one eye causing poor vision and the other eye having good vision or anisometropia may cause strabismus on account of nonuse of the poor eye. This may be either esotropia or exotropia.

Q. A total presbyope whose distance correction is —3.00 D. cyl. ax. 180 wishes reading glasses to read at 13⅓ inches. What would you give put up in simplest form?

Ans. +3.00 D. cylinder ax. 90. Add +3.00 D. sphere to the distance correction and transpose.

Q. Why do lenses which correct ametropia sometimes cause crossed eyes to become straight?

Ans. The eyes often straighten after wearing full ametropic correction when the strabismus is caused by the refractive error, as when the eyes turn in and the patient is hyperopic or turn out and the patient is myopic.

Q. With the Maddox rod over the right eye and the left eye clear, the light is seen to the right of the streak. What kind of diplopia is present and where must the base of the correcting prism be placed to make the streak and the light coincide?

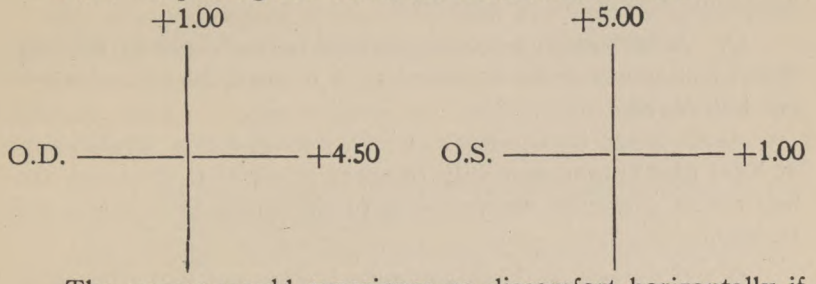
Ans. This would be heteronymous diplopia. The correcting prisms should be placed base in.

Q. In case of anisometropia, with the astigmatism against the rule in one eye and with the rule in the other eye, what would

be the prismatic effect looking 10 mm. below the optical centers of the following prescription:

O.D. +1.00 D. sph. ⊂ +3.50 D. cyl. ax. 90.
O.S. +1.00 D. sph. ⊂ +4.00 D. cyl. ax. 180.

Ans. In putting the Rx. on the cross we have this:



The wearer would experience no discomfort horizontally if the lenses are properly centered, but vertically, while looking 10 mm. below the optical centers, the lenses would produce 4 degrees prismatic effect, base up, over the left eye. This would cause a vertical diplopia in the average pair of eyes.

Q. What does the term "medium" in optics signify?

Ans. The term medium in optics signifies any substance that will transmit light.

Q. About how much difference would you make in fitting a case of anisometropia?

Ans. There is no fixed rule for fitting cases of anisometropia. The refractionist must use his judgment in each case. The general rule is not to make a difference of more than 2 or 3 D. in the power of the lenses.

Q. What would be the principal focal distance of the crystalline lens in air?

Ans. The two radii 6 and 10 divided into the unit 1000 mm. equals +266.6 meter curves. Meter curve multiplied by excess index equals power. Taking the index as 1.43, +266.6 M.C. × .43 excess index = +114.638 dioptric power of lens in air. Power divided in the unit, reduced to millimeters, equals 8.723 mm. as the principal focal distance of the lens in air.

Q. What are the conditions of the eye when in a state of rest if parallel light is focused on the retina? In front of the retina? Behind the retina? Part focused in front of the retina and part behind?

Ans. The respective conditions are emmetropia, myopia, hyperopia and mixed astigmatism.

Q. A certain lens focuses parallel rays of light at 200 mm. What lens power must be added to it to send the focus back to one-half meter?

Ans. Since it requires a +5 D. lens to focus parallel rays of light at 200 mm. and only requires a +2.00 to do so at one-half meter, therefore we must add to the plus 5 D. a minus 3.00 D. lens.

Q. If an eye is overdeveloped ⅔ mm. and has 8 D. of accommodation, what is its range of vision?

Ans. An overdevelopment of ⅔ mm. = 2 D. of myopia; therefore, the far point is at 20 inches. As the accommodation is 8 D., the near point will be at 4 inches. Hence, the range is from 20 inches to 4 inches.

Q. How would you carry out the duction tests?

Ans. With distant correction on patient seated six meters from small light. Rotary prisms are used, placing the apex over the muscles under test and gradually rotating, increasing the power of prisms. The strongest prism power the patient can overcome, without causing diplopia, is the strength or power of the pair of muscles under test. This is expressed in prism diopters.

Q. A test shows patient has a supraduction of the right eye of 4 degrees. The supraduction of the left eye is 2 degrees. What phoria would you suspect and how much?

Ans. Would suspect one degree of right hyperphoria.

Q. In making the duction test at 13⅓ in., how much prism, base in, should a patient fuse?

Ans. Ten degrees, base in, is considered normal. More than 10 degrees is considered to be exophoria, and less than 10 degrees is considered as esophoria.

Q. How many degrees of prism should a person be able to normally overcome, base out, base in, base up, base down?

Ans. A person should normally overcome from 20° to 30° base out, from 6° to 8° base in, and from 2° to 5° base up or down.

Q. An eye whose retina is located beyond the focus of its dioptric system is adopted to what kind of rays of light?

Ans. Such an eye is myopic and is adopted to rays of light starting from a point inside of infinity and enter the eye diverging.

Q. If the focal length is given in centimeters, what is the rule for converting into diopters?

Ans. Divide 100 by the focal length in centimeters, and the quotient will be the dioptric value of the lens.

Q. What is the dioptric power of the lens required to be placed before the static myopic eye of 2.00 D., in order that an aerial image of its illuminated fundus shall be produced 200 mm. in front of the eye?

Ans. With no lens before such an eye there would be an aerial image of the illuminated fundus at ½ meter. To bring this image to a point 200 mm. in front of the eye we must increase the dioptral power of the eye 3.00 D. by adding a +3.00 D. sphere.

Q. Mention two kinds of refractive errors of the eye.

Ans. The two refractive errors of the eye are the spherical errors and astigmatic errors.

Q. Name the different errors of refraction and state kind of lenses required to correct each error.

Ans. Hypermetropia corrected by plus spheres. Myopia corrected by minus spheres and astigmatism corrected by plus or minus cylinders.

Q. Should low refractive errors be corrected?

Ans. Low errors should be corrected with great care. They sometimes cause eye strain. The fact that the refractive error is low does not always mean that the glasses prescribed will

relieve all trouble, as the strain may be due to overuse of the eyes or to asthenopia of some form.

Q. What is dynamic refraction?

Ans. The refraction of the eyes with the accommodation in use and adjusted for near vision.

Q. What errors or refraction cause most headache? State your reason.

Ans. Hypermetropia, hyperopic astigmatism and myopic astigmatism, because there is an excessive use of nerve energy. In all forms of hyperopia and in myopic astigmatism the headaches are caused by strain for better vision.

Q. What errors of refraction may be congenital and which ones acquired?

Ans. Hypermetropia may be original or congenital. Astigmatism and myopia acquired.

Q. How is it possible to construct a refracting system that is corrected for chromatic aberration?

Ans. The index of refraction and the power of dispersion for different kinds of glass are not proportionate and because of this condition, it is possible to construct a refracting system that is achromatic.

Q. What do you understand by a compound refracting system?

Ans. The lens system of the eye is considered a compound refracting system. It has a spherical surface and a bi-convex lens, which together have a principal focus of 20.8 mm.

Q. What do you understand by a dioptric apparatus?

Ans. A dioptric apparatus in its simplest form consists of two media, separated by a spherical surface.

Q. Upon what do the optical properties of such an apparatus depend?

Ans. The optical properties of such an apparatus depend upon the curvature of the surfaces and the relative refractive power, or optical density of the media.

Ophthalmoscopy

Q. Define Ophthalmoscopy.

Ans. Ophthalmoscopy is the examination of the interior of the eye, by means of the ophthalmoscope.

Q. When was the Ophthalmoscope invented, and by whom?

Ans. The Ophthalmoscope was invented in the year 1851 by Helmholz and improved upon by Reute.

Q. What is meant by media in Ophthalmoscopy?

Ans. The media in Ophthalmoscopy are those parts of the eye which transmit the rays of light in the function of seeing. They are the cornea and the aqueous humor, crystalline lens and the vitreous humor.

Q. Name three purposes of using the Ophthalmoscope.

Ans. It may be used by the direct method, to examine the fundus under high magnification by the upright image; to examine the fundus under a low magnification by the inverted image or it may be used to get the refractive error, using the blood vessels in the eye as test types.

Q. What is the principal difficulty in the use of the ophthalmoscope by optometrists?

Ans. The principal difficulty is the smallness of the pupil of the eye under examination. When light is directed into a normal eye by means of the ophthalmoscope the sphincter muscle contracts, closing the pupil.

Q. How can this difficulty be reduced to a minimum?

Ans. The difficulty is best overcome by using the electric ophthalmoscope.

Q. Name the essential constituent parts of the refracting ophthalmoscope and explain their respective functions.

Ans. The mirror is to reflect light upon the fundus, which is to be examined. The perforation in the mirror is so the observer may see the illuminated fundus and the battery of lenses, which will permit the fundus to be seen in focus.

Q. What is the character of the image seen in the direct method of Ophthalmoscopy? Indirect?

Ans. The image is larger, virtual and upright. In the indirect method the image is smaller, inverted and real.

Q. What are the objects of interest seen in the eye when viewed by the ophthalmoscope?

Ans. The objects of interest as seen in a normal eye are the retinal vessels, optic disc and the macula lutea.

Q. How may a patient's accommodation affect the result when the ophthalmoscope is used to determine the refraction?

Ans. If the patient's accommodation is not relaxed, the finding will be an incomplete correction, to the extent that the patient's accommodation acts. If hyperopic more plus is required, if myopic, less minus.

Q. The operator is hyperopic 1.50 D and without his correction is using the direct method of ophthalmoscopy and requires a —4.50 D. lens to view the fundus clearly. What is the kind and amount of the error?

Ans. Combine the operator's condition with the lens that gave the clearest view of the fundus, hence operator is minus 1.50 D. combined with minus 4.50 D. equals minus 6.00 D. The patient is myopic 6.00 D.

Q. The operator is myopic 2.00 D. and without his correction is using the direct method of ophthalmoscopy and requires a minus 3.00 D. to view the fundus clearly. What is the kind and amount of the error?

Ans. Combine the operator's condition with the lens that gave the best view of the fundus, hence the operator's condition is +2.00 D. ⌒ with the minus 3.00 D. lens equals —1.00 D. The patient is hyperopic 1.00 D.

Ophthalmometry

Q. When the ophthalmometer test shows the mire images separated at axis 40, and overlapping at axis 130, what will be the axis of the correcting concave cylinder?

Ans. 130. The mires overlap at the meridian of least refraction, which is the axis for a minus cylinder.

Q. Explain the use of the ophthalmometer.

Ans. It is an instrument built on the order of a telescope, containing several bi-convex lenses and a prism in the tube. Illuminated mires throw images on the surface of the cornea, and these images are reflected back through the tube to the operator's eye. By revolving the mires the operator can detect the presence or absence of corneal astigmatism. In cases of regular astigmatism the principal meridians are located, the radius and dioptric value of each, the amount of astigmatism registered, and whether with or against the rule.

Q. With a double mire ophthalmometer the images just touch in the 65th meridian, but separate in the 155th. Where will the axis of a plus cylinder be placed to correct the error?

Ans. At 65, this being the meridian of greatest refraction

Q. In a case of 2.00 D. of astigmatism, against the rule, what would be the relative powers indicated for the primary and secondary readings of the ophthalmometer?

Ans. The primary reading, being for the principal meridian which lies at or nearest the horizontal meridian of the eye, would be 2.00 D. stronger than the secondary reading. The principal meridian at or nearest the horizontal would register 44 diopters and the vertical meridian at right angles would register 42 diopters which would be against the rule.

Q. Which is the more correct term for the instrument—Keratometer or Ophthalmometer?

Ans. The instrument is a cornea measure only, therefore Keratometer is more correct. Strictly speaking, Ophthalmometer means eye measure.

Retinoscopy

Q. In retinoscopy, where does the light reflex move the fastest, in high or low degrees of ametropia?

Ans. It moves the fastest in low degrees of ametropia.

Q. By static skiametry, if the patient has 2.00 D. of myopic astigmatism in the vertical meridian, how many inches away will

the point of reversal be in the horizontal meridian, when a plus 2.00 D. lens is used?

Ans. In the horizontal meridian, which is emmetropic, the plus 2.00 D. will bring the point of reversal to 20 inches (one-half meter).

Q. By static skiametry, at 40 inches, if the patient has an error correctable with a plus 1.00 D. cyl. ax. 90, what will be the direction of the shadow in the horizontal and vertical meridian, when a plus 1.00 D. lens is used?

Ans. In the horizontal meridian the shadow will be neutral at 40 inches. In the vertical meridian the shadow will go against, with plane, and with, if concave mirror is used.

Q. If with a retinoscope at 16 inches, the point of reversal is reached with a +2.50 sph. ⊃—1.50 cyl. ax. 180 degrees, what would be the prescription for distance?

Ans. When an eye is focused at 16 inches and we want to throw it back to infinity we must combine a minus 2.50 D. sphere with the lenses in front of it. Hence, the answer in this case will be —1.50 cyl. ax. 180 degrees.

Q. The retinoscopic findings of a patient aged 50 years, are as follows: Reversing the shadow between 32″ and 40″, with concave mirror. O. D. +1.75 at meridian 180., —2.00 at meridian 90. O. S. +1.50 at meridian 25, —2.00 at meridian 115. Write prescription from the above findings.

Ans. Working between 32 and 40 inches we add —1.25 to all plus findings and —1.00 to all minus findings, to allow for the working distance.

Rx. O. D. —3.00 D. sph. ⊃+3.50 D. cyl. x 90.

O. S. —3.00 D. sph. ⊃+3.25 cyl. x 115.

Q. What advantage has the concave retinoscope over the plane mirror?

Ans. The concave mirror, held so as to focus the light about in the plane of the cornea of the observed eye, makes opacities and irregularities show up more plainly, and it can also be used, together with a strong plus sphere, in ophthalmoscopy.

Q. A patient is 4.00 D. hyperopic. How can it be proved with a retinoscope and a +6.00 D. lens?

Ans. With a +6.00 D. lens before the patient's eye the point of reversal will be at 20 inches. The allowance for 20 inches is 2.00 D. Therefore, the error must be —4.00 D., and requires a +4.00 D. for correction.

Q. What relation do the speed of the shadow movement and the intensity of the retinal illumination bear to the degree of ametropia?

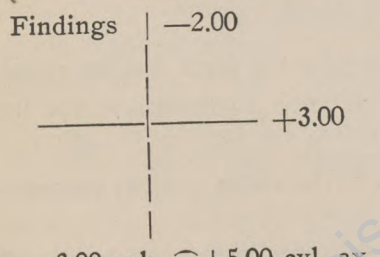
Ans. The slower the speed and the duller the reflex, the greater the degree of ametropia.

Q. With a plus 5.00 D. sph. before the eye the 60th meridian shows point of reversal at 40 inches and the 150th meridian shows point of reversal at 8 inches. What is the distance correction?

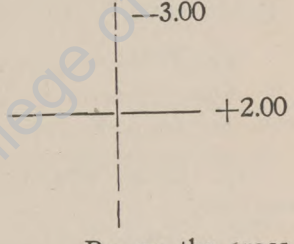
Ans. The eye is hyperopic 4.00 D. in the 60th meridian, and emmetropic in the 150th meridian. Rx. +4.00 cyl. ax. 150.

Q. Retinoscope, static method, patient seated 40 inches from operator. A —2.00 D. neutralizes the vertical meridian and +3.00 the horizontal. Write Rx. for correcting lens.

Ans. Neutralizing at 40 inches the rule is to add minus one to all findings. Rx. on cross:



Rx. —3.00 sph. ⊂+5.00 cyl. ax. 90



Rx. on the cross.

Q. Write a prescription from the following findings with the retinoscope working at one meter distance:

O. D. 90th meridian +2.50 D., 180th meridian +3.25 D.

O. S. 90th meridian +3.00 D., 180th meridian +3.50 D.

Ans. Allowing 1.00 D. for the working distance, the distance Rx. for O. D. will be +1.50 D. sphere ⊃+.75 cyl. ax. 90. O. S. will be +2.00 D. sphere ⊃+.50 cyl. ax. 90.

Q. With a plane mirror working at 20 inches in the usual static method of retinoscopy a +1.00 D. sphere neutralizes the motion in all meridians. What is the full correction for distance?

Ans. The full distance correction will be the algebraic sum of +1.00 D. and —2.00 D. which equals minus 1.00 D.

Q. If the 30th meridian of an eye is .50 D. hyperopic and the 120th meridian is 1.50 D. hyperopic, where is the point of reversal of each meridian when a +4.50 D. sph. is placed before the eye?

Ans. The point of reversal in the 30th meridian would be at 10 inches and in the 120th meridian at 13⅓ inches.

Q. How would you work out a case of mixed astigmatism by retinoscopy using the fogging method?

Ans. Fog the eye so as to make all meridians artificially myopic. Then reduce the fog until the shadow is neutral in the hyperopic meridian. Then use minus cylinders, placing the axis over the neutral meridian increasing the power of the cylinder until the myopic meridian is also neutralized. Then make the allowance for the working distance.

Q. What do you understand by the term "retinal reflex"?

Ans. A term used in retinoscopy to designate the light reflected from the retina and creating the light in the pupil.

Q. Under what conditions is the static method considered the best?

Ans. When the patient is myopic, presbyopic, and in case of muscular imbalance.

Q. Under what conditions is the dynamic method considered best?

Ans. When the patient is hyperopic, with active accom-

modation, in latent hypermetropia and in cases of spasm of accommodation.

Q. What method of skiametry eliminates the use of a cycloplegic in determining the measure of ametropia?

Ans. This claim is made for dynamic skiametry.

Q. If with a healthy patient age 25 years you find with the retinoscope 4.50 D. of hyperopic astigmatism, would you really rely on this to prescribe the —4.50 D. cyl.?

Ans. Retinoscopic findings should always be proved up, by means of the trial case examination. Astigmatism should be measured by the ophthalmometer. The rule is to give full correction, but in high errors it is advisable in some cases to prescribe partial correction and gradually increase to full correction. How much is a matter of experience and judgment.

Q. Can the concave retinoscope be used as an ophthalmoscope? How?

Ans. Yes. In conjunction with a strong plus lens of about 16 diopters. Employing the indirect method of ophthalmoscopy.

Q. The retinoscopic findings working at one meter, employing the static method are O. D. +3.00 horizontally, and +2.00 vertically. O. S. +2.50 vertically and +2.75 horizontally. Write Rx.

Ans. The rule is to add minus one D. to all findings working at one meter distance.

Rx. O. D. +1.00 sph. ⊃+1.00 cyl. ax. 90.
O. S. +1.50 sph. ⊃+ .25 cyl. ax. 90.

Q. How should the retinoscope be held while making an examination of the eye?

Ans. The retinoscope should be held in about the same manner as the ophthalmoscope. The sight hole should be directly before the pupil and the examiner should keep both eyes open.

Q. A hyperope of ½ D. is fixing at 40 inches, and the operator is working at 20 inches. What lens will bring point of reversal?

Ans. Dynamic skiametry +1.50 D. sph.

Q. A myope of ½ D. is fixing at 40 inches. What lens power will bring point of reversal to observer at 16 inches?

Ans. Static skiametry +2.00 D. sph.

Q. An emmetrope is fixing at 40 inches, what lens power will bring the point of reversal to observer at 16 inches?

Ans. Dynamic +1.50 D. sph. Static +2.50 D. sph.

Q. Working at 40 inches from a patient, a plus 2.00 D. sphere neutralizes the shadow movement. What two points are conjugate, and what is the patient's distance correction?

Ans. The conjugate points are the retina of the patient's eye, and the nodal point of the observer's eye. The distance correction is +1.00 D. sph. found by adding —1.00 D. to the +2.00 D. to neutralize the working distance.

Q. In retinoscopy, what is indicated by the speed of the shadow? By the direction of the shadow? By the form of the shadow?

Ans. By the speed of the shadow the measure of the refractive error may be estimated. When the refractive error is high the shadow moves slow and sluggish. The higher the error the slower the shadow movement will be. The direction of the shadow indicates the character of the refractive error, with working distance neutralized by a plus spherical lens of proper strength. Using a plane mirror against motion indicates myopia, and with motion indicates hypermetropia. Using the concave mirror against motion indicates hypermetropia and with motion indicates myopia. The form of the shadow indicates the character of the error, whether spherical or astigmatic. If the edge of the shadow is straight or band like in appearance, it indicates astigmatism. If the shadow is curved or rounded on the edge, like a full moon, no astigmatic error is indicated.

Q. In what respect does dynamic skiametry differ from the static method?

Ans. In the static method the test is made with the accommodation at rest. In the dynamic method the accommodation

is in use. Usually this is done by means of a fixation chart attached to the retinoscope or to the forehead of the operator.

Q. Do you think the skiascope a good test for detecting astigmatism and the axis of the cylinder?

Ans. Yes. Skiascopy is an excellent method for detecting astigmatism and locating the principal meridians, except in very low errors when the band appearance is often hard to make out.

Q. With the plain retinoscope, working between 32 and 40 inches, +2.50 reverses the shadow in the 90th meridian, and —.75 in the 180th meridian. Write the correction from this finding.

Ans. Working between 32 and 40 inches we add —1.25 to all plus findings and add —1.00 to all minus findings. This neutralizes the working distance and places the patient's far point of vision out to infinity.

Rx. —1.75 sph. ⊃+3.00 cyl. ax. 180.

Q. In dynamic skiametry, using the plane mirror with fixation of 40 inches and observation at 26 inches, will the shadow movement be with or against if the eye is emmetropic?

Ans. The movement will be with for the eye is focused farther away than the observer.

Q. If the observed eye is myopic 1.50 D. and the operator is using a concave retinoscope in the static test, what will be the direction of the shadow at 16 inches? At 40 inches?

Ans. At 16 inches motion of the shadow will be against the mirror, since the operator is within the point of reversal (27 in.). At 40 inches motion of shadow will be with the mirror, since operator is beyond the point of reversal.

Q. On what principle is shadow testing based?

Ans. Shadow testing is based upon the principle of conjugate foci, the point of reversal and the retina are interchangeable or in conjugate relationship.

Q. How can you prove with a plane retinoscope a tape measure and a plus 5.00 D. sphere that the patient is hyperopic 3.00 D.?

Ans. Assuming that the retinoscope is of the illuminated type, would place the plus 5.00 D. sph. in the trial frame, properly adjusted and in position on the patient. The lens could also be held in position before the eye under examination and if the point of reversal was found to be at 20 inches, O. U., it would indicate that the patient was hyperopic, 3.00 diopters.

Q. In dynamic retinoscopy are both eyes kept open or is one covered?

Ans. Since dynamic retinoscopy depends upon the harmonious relationship between accommodation and convergence, it is necessary that the patient fix with both eyes. The operator may also have both eyes open.

Q. When is the shadow neutralized in retinoscopy?

Ans. When the retina of a patient and the nodal point of the observer's eye are conjugate.

Q. Explain the dynamic method of skiametry and its purpose.

Ans. In this method a card of letters is attached to the retinoscope, at which the patient is asked to look, using both eyes. Then lenses are used in the customary way to find the point of reversal. A definite amount of accommodation is used, corresponding to the distance of fixation, which reduces the tendency to spasm. The test can be made at the usual distance and the findings represent the amount of error or correction, as no allowance is made for the working distance.

Q. What do you understand by point of reversal in retinoscopy?

Ans. The term is used to designate the point between an upright and an inverted image, the point where the converging rays change to divergent rays. If a fogging lens be employed, or in myopic eyes it would be where the movement of the reflex appears lost.

Q. Working at 16 inches, static method, neutrality is reached with +2.50 sph. ⊃—1.75 cyl. ax. 180. What is the prescription for distance?

Ans. The working distance being 16 inches there must be an allowance of 2.50 D., therefore, the distance correction will be minus 1.75 cyl. ax. 180.

Q. The operator has an uncorrected error of refraction equal to one diopter of myopia. Works at one meter with the plane mirror, and finds all meridians of the shadow neutralized by a +3.50 D. sph. What effect has his own uncorrected error on the findings?

Ans. The operator's ametropic condition has no effect on the findings except that his visual acuity must be such as to enable him to observe the shadow movements. The Rx. for above findings equals +2.50 D. sph. To all plus findings at 40 inches add —1.00 D.

Q. What deduction is made in retinoscopy when using the dynamic method with fixation target one meter from the eye?

Ans. There is no deduction made when using the dynamic method as the distance of fixation and observation should be the same.

Q. In your findings with the retinoscope, when do you add and when do you subtract?

Ans. Always add a minus 1.00 D. to the sphere in the trial frame, or what is the same thing, take a plus 1.00 D. away from the sphere in the trial frame, when working at one meter distance, when the static method is employed.

Q. Which lenses are used to neutralize a shadow movement with and against the plane mirror, respectively?

Ans. Using the plane mirror, motion with is neutralized by means of plus lenses and against motion by minus lenses.

Q. What is the main objection to the use of the concave mirror in retinoscopy?

Ans. The concave mirror cannot be used in the dynamic method, it reflects too much light into the eye as its focal length is usually only ten inches.

Chapter VIII
FRAME FITTING

Q. (a) Explain difference in construction of a riding bow spectacle and an eyeglass mounting.

(b) Name integral parts of each, and function of each part.

Ans. (a) Riding bow frame is usually constructed with a saddle bridge intended to rest lightly on the nose. The said bridge is connected with lenses or eye wires at nasal sides. Also consists of pair of hooked temples that fit around the ears and hold the bridge in position.

Finger piece eyeglasses, which is the style used most frequently today, consists of a rigid bridge and pair of finer pieces attached to guards which engage the nose, the pressure of same being regulated by a pair of coil springs. The old style spring mounting consists of guards, studs and spring. The three parts being held together by stud screws; the guards engage the nose and are held in position by the spring.

(b) The integral parts of the spectacle are the bridge, end pieces and the temples. The bridge governs the horizontal position of the lenses and determines the distance that the lenses set from the face. As they are responsible for maintaining the correct position of the lenses, it is always desirable to have the bridge as stiff as possible. The end pieces are connected with the eye wires, or lenses, at the outer edge, and are connecting links between the lenses and the temples. They also aid in getting the required distance between temples in order to relieve pressure at side of head. Temples connect with the end pieces and are bent to fit the ears in order that the lenses and bridge may be held in position.

Finger piece eyeglass mountings consist of a rigid bridge which rides the nose, a pair of finger pieces and guards, and a

pair of coil springs and post screws. The guards and springs are held in position by post screw and the tension of the guards which engage the nose, is regulated by the coiled springs.

Q. What is considered the backbone or foundation on which a riding bow spectacle is constructed?

Ans. Bridge or nose piece.

Q. (a) Name measurements in order of their recognized importance, that are usually observed when fitting a spectacle frame.

(b) Give brief explanation of your method of procedure in taking same.

Ans. (a) Pupillary distance (P. D.); height of crest; inclination of position of crest forward or back of posterior plane of lenses; angle of crest; width of base; length of temples; size and shape of lenses.

Ans. (b) In taking the above measurements the P. D. should be measured by measuring from the inside edge of one iris to the outer edge of the other, with eyes fixed at infinity. This will equal the distance from center to center of the pupils and will be much more easily measured.

Other measurements should be taken with the aid of the riding bow fitting set, marked according to the saddle bridge system; the bridge of sufficient height to drop the lenses so that the horizontal lines on lenses of fitting frames will come on a line with the lower edge of the pupil.

The inclination of the bridge which regulates the distance that the lenses are to set from the face, can be determined by the length of the shanks, which will set the bridge either forward, even or back of plane. A bridge which will permit the lenses to set as close as possible to the eyes without interfering with the lashes, should always be selected. Angle of the bridge of the frame fitting being 45° it will be easy to determine whether the angle should be increased or diminished. This measurement is always figured from the vertical plane of the

face, which is 90°. If top edge of crest cuts, angle would be increased; if lower edge cuts, angle should be diminished.

The width of base can be determined by letters used in marking frames, and should always be sufficiently wide to permit bridge to fit the contour of nose without binding. Total length of temple, which is the most desirable way of ordering, can be determined by trying fitting frames on patient, as these frames, as a rule, come fitted with 6 inch and 6½ inch temples. Temples should be long enough to fit the curve of the ear without binding. Size and shape of lenses will then be determined by comparing the pupillary distance with the spread required to fit the nose and the general features of the patient.

Q. (a) Give brief explanation of the saddle bridge system.

(b) What are the measurements of an N′, or extra long shank bridge?

(c) If an extra long shank bridge sets lenses too far from eyes, and a regular shank bridge interfered with lashes, what measurement would you prescribe?

(d) If a bridge set ¼ inch above the pupillary line set lenses ⅛ of an inch too low, would you order bridge raised or lowered, and how much, to get correct position?

(e) Give base measurement of M′ N′ O′ bridges.

Ans. (a) The saddle bridge system is used to denote measurements of the saddle bridge. This system consists of letters and figures; the letters indicate the width of the base, and the figures denote the height of crest.

M, N and O are most commonly used, and are ⅝″, ¾″ and ⅞″ in width, respectively. A unit is equivalent to ⅛ of an inch and if letter indicating the width is followed by figure (1), it indicates that the bridge is ⅛ of an inch above the pupillary line. Figure (2) would indicate that the bridge is 2/8 or ¼ of an inch above pupillary line. There are three commonly accepted terms to indicate the inclination of the crest—regular shank (R. S.), 1/16 back. As a rule, regular length shanks are used; there is no reference made to these measurements. For

example, if a frame is marked Ml, it would be understood that the bridge was 5/8 at the base, 1/8 high and 1/16 forward. Occasionally the term "inset" is used instead of "extra long shank." In all such cases it is understood that the bridge is 1/16 back of plane.

(b) N 1 outset equals 3/4 base, 1/8 high, 1/16 back.

(c) Long shank bridge, crest even.

(d) Bridge should be lowered 1/8 to raise lenses.

(e) M 1 equals 5/8; N 1 equals 3/4; O 1 equals 7/8.

Q. (a) If a patient with a pupillary distance of 60 mm. requires a spread of 22 mm. between inner edges of lenses, what length of lens would you prescribe in order to get the correct pupillary distance without decentering lenses?

(b) How much would you decenter each lens, and in what direction, in case a lense 36x44 mm. was ordered?

(c) What is the true pupillary distance of a pair of glasses?

(d) Why is it possible in many cases to use a longer lens with a spectacle frame, than it is with a finger piece eyeglass?

Ans. (a) 38 mm. long.

(b) Decenter each lens in 3 mm.

(c) Distance between optical centers.

(d) Due to possibility of bending saddle bridge, not afforded by the rigid bridge finger piece mounting.

Q. Give brief explanation of the system used in numbering finger piece eyeglass mountings. Give measurements of following sizes: 0412, 0512, 0622, 0733, when fitted with 00 eye size lenses.

Ans. System used in numbering finger piece mountings represents P. D. height and inclination of crest; a unit being equivalent to 1/16 of an inch; zero preceding figures indicate that short bridge construction has been used.

No. 0412 P. D. 2¼x1/16Hx⅛F.
No. 0512 P. D. 2 5/16x1/16Hx⅛F.
No. 0622 P. D. 2 6/16x⅛Hx⅛F.
No. 0733 P. D. 2 7/16x3/16Hx3/16F.
No. 0844 P. D. 2½x¼Hx¼F.

The above pupillary distance is based upon 00 eye size lens. If larger lens is used, P. D. will be increased.

Q. (a) Give rule that is always observed (when fitting a finger piece eyeglass) in determining size of lens needed to maintain correct P. D. without decentering lenses.

(b) Name two ways of getting correct P. D. in following case: P. D. 63 mm.; distance between straps of mounting, 22mm.; lens ordered 38x44 mm. leaf shape.

(c) When are leaf shape lenses more desirable (for cosmetic reason only) than regular or short oval lenses?

Ans. (a) Distance between straps or inner edges of lenses plus the length of one lens equals the P. D. Features of patient will determine width of lens.

(b) Decenter each lens in 1½ mm. or grind lenses with Adapto cut 1½ mm. deep.

(c) When patient has protruding brow or deep-set eyes.

Q. Why are the segments of bifocals, as a rule, set in toward the nose 1½ mm. on each side?

Ans. To allow for convergence of eyes when fixed for near vision.

Q. Submit two prescriptions as you fill them out, if ordering from your jobber—one for spectacles to be worn for general use—the other for eyeglasses with bifocal lenses.

Ans. Spectacles:

Date..... Name of Patient..... P. D. 62 mm.

Rx. O. D. +1.00 sph. ⌒+.50 cyl. x 90.

O. S. +1.25 sph. ⌒+.75 cyl. x 90.

42x35 S. O. Leaf, Toric, N 1, Bridge Rimless G. F., four holes, 6 inch Comfort temples.

Drs. Name.....

Eyeglasses:

Date.....Name of Patient.....P. D. 61 mm.

Rx. O. D. +1.50 sph. ⌒—.50 cyl. x 75.

O. S. +2.00 sph. ⌒—.50 cyl. x 105.

Add for reading:

O. D. +1.00, O. S. +1.00. Displace each scale in 1½ mm. Kryptoks, 40x34 S. O. Rimless, three holes, Toric, Fits N 0622.

Drs. Name.....

Q. Give the three principles that must be observed in order to insure a perfect fitting pair of spectacles or eyeglasses.

Ans. (1) Correct position.
(2) Comfort of patient.
(3) Neatness in construction.

Q. What do the figures indicate when ordering a finger piece mounting, i. e., Fits N 0522?

Ans. The first figure, "O" indicates "shore bridge." The second figure indicates the pupillary distance in sixteenths of an inch above 2 inches for 00 eye lenses, therefore the second figure 5 indicates a P. D. of 2 5/16. The third figure indicates the height of the bridge in sixteenths and the fourth figure indicates the inclination of the bridge in sixteenths beyond the plane of lenses. The above inch measurements may be reduced to their metric equivalents.

Q. How are the dimensions for fitting spectacles best obtained?

Ans. The required dimensions are best obtained by the aid of a trial set of fitting frames.

Q. What is the average angle of crest?

Ans. The average angle of crest is about 45 degrees.

Q. What is the effect if the bridge selected is too narrow?

Ans. When the bridge is too narrow, the lenses tip forward at the top and come off easily.

Q. Is it possible to raise or lower the lenses fitted in a finger piece mounting?

Ans. The lenses may be raised or lowered about 1½ mm. by guard adjustments. To lower the lenses the guard must be raised. To raise the lenses the guard must be lowered. After

this adjustment is made the guards should be set at the proper angle again. The guards may also be angled back or forward to tilt the lenses when required. Angling the tops of the guards back toward the eyes will tilt the lenses out at the top and give a pantoscopic effect. Angling the tops of the guards away from the eyes will tilt the lenses in toward the eyes at the top, producing a retroscopic effect.

Q. What is the chief advantage of the narrow P. D. Fits-U Mounting?

Ans. The narrow P. D. Fits-U Mounting enables one to use larger lenses because it gives the same guard spread and bridge width as the regular mounting with 3 mm. less P. D. Therefore, it allows the use of lenses 1½ mm. larger horizontally than the regular mounting to get any given P. D.

Q. Give dimensions of standard saddle bridges in millimeters and inches.

Ans.

Bridge Number	M	M½	M¹	M¹½	M²	N	N½	N¹	N¹½	N²	N²½	N³	O¹	O¹½	O²	O³	P³
Height Millimeters	0	1½	3	4½	6	0	1½	3	4½	7	7½	9	3	4½	6	9	9
Height Inches	0	1/16	1/8	3/16	1/4	0	1/16	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	3/8	3/8
Base Millimeters	15	15	15	15	15	18	18	18	18	18	18	19	21	21	21	22	25
Base Inches	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	13/16	7/8	7/8	7/8	15/16	1

Q. Name the cardinal dimensions necessary in ordering spectacles.

Ans. P. D. size, shape and form of lenses, height of bridge, width at base of bridge, inclination of bridge, angle of crest, temple length to back of ear, total length of temples, width between temples and the angle of joint.

Chapter IX
DISEASES OF THE EYE

Q. What is cataract?

Ans. Cataract is a loss of transparency in the crystalline lens, its capsule or both. It shows as an opacity of the lens when the ophthalmoscope or retinoscope is used.

Q. Name several kinds of cataracts?

Ans. Senile, congenital, traumatic, capsular, cortical, nuclear, anterior and posterior, zonular, amber, after cataracts and pyramidal cataracts.

Q. What is meant by the term capsulo-lenticular cataract?

Ans. This term is used when both the crystalline lens and its capsule are opaque.

Q. Compare the effects in vision as between a developing cataract and toxic amblyopia?

Ans. In cataract, near vision is better in comparison with distant vision, while in toxic amblyopia distant vision is better in proportion with near vision.

Q. What is a zonular cataract?

Ans. A form of cataract in which the opacity is limited to a few layers of the lens, next to the nucleus.

Q. What effect would exposure to irritating atmosphere such as wind, dust, smoke, etc., likely produce on the eye?

Ans. Particles of dust, coal or ashes usually lodge on the inner surface of the upper lid, causing severe pain. They can be removed after everting the lid. Exposure to dust, wind, etc., also causes a growth on the conjunctiva known as Pterygium.

Q. What would you tell a patient who describes symptoms of muscae volitantes?

Ans. That it is nothing to be alarmed about, and does not indicate anything seriously wrong with the eyes.

Q. What is iritis?

Ans. Iritis is an inflammation of the iris.

Q. Give four subjective symptoms of iritis?

Ans. Pain, loss of vision, photophobia and lachrymation, or excessive flow of tears.

Q. Give three objective signs of iritis?

Ans. Irregularly contracted pupil. Iris a darker color than the fellow eye, and has a muddy appearance; the aqueous humor becomes turbid or milky. A zone of fine vessels surrounding cornea and fading toward fornix, or so-called circum-corneal injection.

Q. What is liable to happen to an eye that is attacked with iritis if uncontrolled?

Ans. A secondary glaucoma is liable to follow due to posterior annular synechia or sechesio pupillae or the exduate in the pupillary area may become organized. This fills in the pupil and shuts out the light, or exclusio pupillae.

Q. Name the varieties of conjunctivitis?

Ans. Simple, catarrhal, purulent, membranous, granular or trachoma, chronic, catarrhal due to eye strain.

Q. What is conjunctivitis? (b) Cyclitis?

Ans. Inflammation of the conjunctiva. (b) Cyclitis is inflammation of the ciliary bodies.

Q. Name the different kinds of styes or hordeolum?

Ans. External, when two or more of Zeiss's glands are infected and separate. Internal, when one or more of the Meibomian glands are infected and separate. A reddish swelling appears at the margin of the lid accompanied by pain and tenderness.

Q. What is a chalazion?

Ans. A chalazion is a cystic tumor on the eyelid, due to an enlargement of one or more of the Meibomian glands. The tumor is firm with the skin moving freely over the enlargement, but it is firmly attached to the tarsal plate, also known as Meibomian cyst.

Q. If there is a sudden change in the refraction and there is an acquired hypermetropia produced, what three diseases may be suspected?

Ans. Either glaucoma, diabetes or high blood tension as seen in arterio-sclerosis.

Q. What happens if there is interference with the functions of the nasal portion of the lachrymal apparatus?

Ans. It causes a stoppage of the flow of tears through to the nasal spaces, and there is epiphora, or an overflow of tears.

Q. What is sclerosis?

Ans. Sclerosis is the process of becoming hard, as in the hardening of the blood vessels and other tissues.

Q. What are the signs of arterio-sclerosis, both subjective and objective?

Ans. The subjective signs are dizziness and shortness of breath and headaches. The objective signs are nose bleed, Sub. conjunctival hemorrhage, Sub. hyoloid hemorrhage, corkscrew-like endings, and bead-like appearance of the small vessels in the retinae. Tortuosity of the arteries in the retinae. Diffuse edematous lines along the sides of the retinal vessels, discreet or sharply defined white lines along the sides of the arteries. Opaque arteries and compression of the veins where arteries lie on or cross them.

Q. What are the dangers to the patient who is afflicted with arterio-sclerosis?

Ans. Apoplexy, paralysis and retinal hemorrhages, the latter causing blindness.

Q. What is capsulitis?

Ans. Inflammation of the capsule of the crystalline lens.

Q. What is embolism? (b) Thrombosis?

Ans. Embolism is an obstruction of a vessel by a clot of blood—an embolus. If an embolism occurs in the retinal vessels, vision is lost instantaneously in area supplied by it. Thrombosis is the formation of a blood clot in the retinal vessels at the point of obstruction. When it occurs in the central artery of the retina there is a gradual falling off of vision.

Q. What is enucleation? (b) Glioma? (c) Hyalitis?

Ans. Enucleation is an operation for the removal of the eye ball. Glioma is a variety of malignant tumor which develops in nervous tissue and often develops in the retinae. Hyalitis is an inflammation which affects the hyaloid membrane or vitreous humor.

Q. What is post ocular neuritis? Pannus? Retinitis?

Ans. Post ocular neuritis is an inflammation of the optic nerve. Pannus (like cloth) consists of a thin grayish opacity of the cornea usually covering the upper half of the cornea, where it is the result of granular conjunctivitis. Retinitis is inflammation of the retina.

Q. Give cause of atrophy of the optic nerve?

Ans. Atrophy of the optic nerve is due to the degeneration of the optic nerve and usually follows in the wake of optic neuritis.

Q. What does car sickness usually indicate?

Ans. Muscular imbalances, or it may be due to refractive errors.

Q. Name the common affections of the eyelids?

Ans. The common affections of the eyelids are blepharitis, styes, trichiasis blepharochalasis, ptosis entropion, tumors, cysts, ectropion and injuries.

Q. What is meant by detachment of the retina? What would cause it?

Ans. Retinal detachment is a separation of the nine innermost layers of the retina from the tenth or pigment layer. Detachment may be due to disease or injury and is often found in high degrees of myopia.

Q. What is a Meibomian cyst?

Ans. A Meibomian cyst or chalazion is a cyst in the eyelid, and is usually the result of closure of the ducts leading from the Meibomian glands.

Q. What is synechia?

Ans. Adhesion, as of the iris to the lens capsule (posterior) or cornea (anterior) as the result of iritis.

Q. What is the condition called when the retina is over sensitive to light?

Ans. Retinal asthenopia and usually produces photophobia.

Q. Describe cramp, paresis and paralysis?

Ans. Cramp is a spasmodic muscular contraction with pain. Paresis is a slight form or degree of paralysis which partially impairs muscular action. Paralysis means a loss of power, complete impairment of one or more of the motor and sensory nerves.

Q. What is pinguecula?

Ans. A small yellowish white conjunctival tumor, and is usually situated in the conjunctiva near the margin of the cornea on the nasal side.

Q. What is glaucoma?

Ans. A disease of the eye usually characterized by increased intraocular tension due to a stoppage of the drainage system of the eye.

Q. Name the different forms of glaucoma?

Ans. Absolute, acute inflammatory, chronic inflammatory, hemorrhagic, infantile, primary, secondary and chronic sub acute.

Q. Give four subjective symptoms of primary acute glaucoma?

Ans. Flashes of light, haloes around lights, colored rings surrounding lights. (2) Feeling of fullness in the eye with watering and discomfort. (3) Disturbance of and rapid falling off of vision. (4) Pain of a throbbing or neuralgic nature.

Q. What is the treatment for glaucoma?

Ans. Myotic to contract the pupil and an iridectomy. If untreated, glaucoma always results in incurable blindness.

Q. Describe chronic sub acute glaucoma?

Ans. This form of glaucoma runs its course without pain, inflammation, rise of tension, dilation of pupil or changes in the cornea and aqueous humor. The diagnosis is made by the history of gradual loss of visual acuity. The contractions of the

visual field, especially at nasal side, the cupping of the optic disc is well marked and there are gradual atrophic changes.

Q. Give six objective symptoms of acute primary glaucoma?

Ans. (1) Anterior ciliary veins are engorged. (2) Dilated pupil. (3) On palpation the eye ball feels firm and hard. (4) shallow anterior chamber and aqueous looks hazy and turbid, and later there is a greenish reflex from the pupil. (5) The eye ball is hard due to the increased inter-ocular tension. (6) Cupping of the disc, when viewed with the ophthalmoscope.

Q. Explain the cupping of the optic disc due to glaucoma?

Ans. The accumulation of fluids in the eyeball so increases the intra-ocular pressure that the lamina crosbrosa gives way and the tissues are forced backward. The cupping usually begins on the temporal side, at the margin of the disc, and develops into a deep pouch-like cup if not controlled.

Q. What changes in refraction may take place in glaucoma?

Ans. In the early stages there may be a rapid development of hypermetropia, and more or less loss of accommodation, then a gradual returning to normal, and even later the eye may become myopic. This is due to the changes in the position of the crystalline lens at different stages of the disease.

Q. What is ophthalmia neonatorum?

Ans. A form of purulent conjunctivitis which attacks the eyes of newly-born children. This disease generally appears from the second to the fourth day after birth, and is usually binocular. Statistics show that in the United States nearly 30 per cent of the blind have lost their sight as the result of ophthalmia neonatorum. This disease is highly contagious, and is due to gonorrhoeal infection.

Q. What change in refraction takes place in the earliest stages of sympathetic ophthalmia?

Ans. Accommodation is lost and premature presbyopia is present.

Q. What is sympathetic ophthalmitis?

Ans. An inflammatory condition of the Uveal tract in one eye which is caused by an injury or disease of the other eye.

Q. What can be done to prevent sympathetic ophthalmia?

Ans. Enucleation, if resorted to in time, will prevent sympathetic ophthalmia, but if delayed until the inflammation has progressed is of little value.

Q. What effect does an embolism of the arterio centralis retinae have on vision?

Ans. Vision is lost instantaneously.

Q. What eye disturbance is caused by a brain tumor?

Ans. Swelling of the nerve head or so-called choked disc.

Q. What is meant by term choked disc?

Ans. That condition in which there is a swelling of the optic papilla or disc, and is one form of papillitis due to the forcing of the cerebro spinal fluid from the ventricles of the brain into the inter-voquial space of the optic nerve.

Q. What is the first subjective symptom of detachment of the retina?

Ans. There will be bright flashes of light in a fixed, definite area of the field of vision.

Q. What refractive error is liable to produce detachment of the retina?

Ans. High degree of myopia.

Q. Describe the disease known as blepharitis marginalis?

Ans. Inflammation at the margin of the eyelid. There are two forms, squamous ulcerous and squamous or scaly. In the ulcerous form the lids are red and swollen near the margins; yellow crusts form, which cause the lashes to mat together. Small ulcers lie under these crusts surrounding the lashes. If the disease is allowed to run on the lashes gradually fall out and are not replaced, since the hair follicles are destroyed. The squamous non-ulcerous form appears much the same as the ulcerous. Scales form around the bases of the lashes and the

lashes fall out but are replaced, since the follicles are not destroyed. In both forms there is itching, burning, discomfort and photophobia.

Q. Name and describe two diseases of the conjunctiva?

Ans. Granular conjunctivitis or trachoma is a severe inflammation with small elevations forming on the palperal conjunctiva. The membrane itself becomes thick and rough. There is generally photophobia, lachrymation, itching and burning sensation and disturbance of vision due to the pannus developed in the cornea. Follicular conjunctivitis, a catarrhal form, with the presence of round pink bodies about the size of a pin's head on palperal conjunctiva of the lower lid. It is a chronic affection often lasting for months.

Q. What is amaurosis?

Ans. Amaurosis is the name applied to a disease of the optic nerve or retina, which causes absolute blindness.

Q. What is coloboma?

Ans. Coloboma is that condition in which there is a break, cleft, tear or fissure in the eyeball as in the choroid or iris and is either traumatic or congenital in origin.

Q. What is the arcus senilis?

Ans. A white circle in the cornea near the scleratic. It is commonly supposed the arcus senilis denotes old age and also fatty degeneration. This is not always true, as it is often present in middle-aged people who are strong and have healthy eyes. It does not interfere with sight nor signify that a serious eye disease is present. There is always a narrow margin of normal transparent corneal tissue between the limbus and the opaque tissue.

Q. What is indicated by a woolly appearance of the optic nerve head?

Ans. The term "woolly appearance" is sometimes used in papillitis, meaning an inflammation of the optic papilla, where there is an exudate present which causes a blurring of the outlines of the nerve and blood vessels.

Q. Name a disease of the eyes that prevents immigrants affected by it from landing in this country?

Ans. The disease is trachoma (granular or Egyptian conjunctivitis), a disease of the conjunctiva of a contagious and destructive nature. It causes total blindness if not controlled.

Q. What is pink eye, pterygium?

Ans. Pink eye is a catarrhal conjunctivitis characterized by a small petechial hemorrhage in the conjunctiva causing a rosy or pinkish color. Pterygium is a growth on the conjunctiva usually on the nasal side growing out over the cornea.

Q. What is scleritis?

Ans. Scleritis is an inflammation of the sclerotic coat.

Q. What is blepharitis? Is this a serious disease?

Ans. Blepharitis is an inflammation of the margin of the eye lid. It is serious in that it results in loss of the lashes, entropium, or ectropium, which render the eye liable to injury from wind, dust and foreign bodies.

Q. What conditions may produce blepharitis?

Ans. Hypermetropia or improper hygienic care of the eyes. It may also be produced by rubbing the lids.

Q. What is Leber's disease of the optic nerve?

Ans. Hereditary atrophy of the optic nerve, and usually develops in middle age.

Q. What is amblyopia?

Ans. Defective vision, usually affecting one eye. It is frequently associated with high degree of ametropia. Any interference with vision which prevents perfect focusing upon the retina causes amblyopia from non-use.

Q. Name two varieties of amblyopia?

Ans. Congenital and amblyopia exanopsia, resulting from non-use. This form of amblyopia is rarely developed after the age of 12 years.

Q. What is toxic amblyopia? What causes it?

Ans. Amblyopia caused by a poison, a common cause being

excessive use of tobacco or alcoholics or both. It may be caused by diseases of the accessory sinus of the nasal cavities and lead poisoning.

Q. What is meant by floating spots in the eye?

Ans. They are small obstructions to vision which are the shadows of small floating particles in the humors of the eye, mostly in the vitreous humor, also known as muscae volitantes.

Q. What is trichiasis?

Ans. Trichiasis is that condition in which the eye lashes turn in upon the eye-ball, causing irritation and discomfort.

Q. What is phakitis?

Ans. Phakitis would mean an inflammation of the crystalline lens. This is a condition that cannot exist because there are no blood vessels in the crystalline lens to support an inflammatory process.

Q. What is staphyloma?

Ans. Staphyloma is a bulging of the eye. If backward, it is called a posterior staphyloma. If to the front, an anterior staphyloma.

Q. What is meant by atrophy?

Ans. Atrophy is the loss of vitality or wasting away usually due to a lack of nutrition.

Q. What is exophthalmos? Hypopyon?

Ans. Exophthalmos is an abnormal protrusion of the eye-ball. Hypopyon is pus in the anterior chamber of the eye.

Q. What is scotoma?

Ans. Scotoma is a defect within the retina, a blind or partially blind area in the visual field.

Q. Describe scintillating scotoma?

Ans. Scintillating scotoma is a form of temporary blindness preceded by lightning-like flashes of light, and characterized by defects in the visual fields. The attacks vary in frequency and in duration they sometimes last for thirty minutes, and are

usually followed by a severe migraine. The attacks are brought on by hunger, protracted reading or close work, fatigue and eye strain of any kind. Errors of refraction or any heterophoria should be neutralized, and attention given to the general health.

ADDITION TO PHYSIOLOGIC OPTICS.

Q. What is asthenopia and name three kinds?

Ans. Asthenopia is weak, tired and uncomfortable vision. The three kinds are retinal, muscular and accommodative.

Q. What is second sight?

Ans. Second sight is a term applied to a condition after presbyopia has set in and the patient requires glasses for near vision. There occurs a gradual increase in the dioptric power of the eye. The patient gradually becomes myopic to the extent that glasses are no longer required for near vision. This is due to the swelling of the fibers in the crystalline lens, which is usually an indication of an incipient cataract. This usually develops into a senile cataract.

Q. What is aphakia?

Ans. Aphakia is that ocular condition when the eyeball no longer contains its crystalline lens.

Q. What is conical cornea and its causes?

Ans. Conical cornea is a bulging forward of the cornea in a pointed form. It is due to the cornea being too weak for the pressure in the eyeball.

Q. What is achromatopsia?

Ans. Total color blindness. This is not in reality a blindness but an inability on the part of the patient to distinguish certain colors. Congenital color blindness occurs in from three to four per cent of males, and in only one-tenth of one per cent of females. It generally affects both eyes, and is often hereditary.

Q. What is conical cornea? Cupped disc?

Ans. A cone-like protrusion anteriorly of the cornea. Cupped disc is that condition of the eye in which the optic disc has become cupped as the result of glaucoma.

Q. What is iridodonesis? What causes it?

Ans. Trembling condition of the iris. If the lens is absent,

then the iris vibrates with the movement of the eyeball. This condition of the iris is known as iridodonesis, and is caused by the loss of support which the iris receives from the lens.

Q. What is ectropion? Entropion?

Ans. Turning inside out of the edge of an eyelid, exposing the lining of the lid to wind and dust. Entropium is that condition where the edge of the lid turns back or in. Thus the celia scratch the cornea.

Q. What is a cycloplegic? Mydriatic? Myotic?

Ans. A drug or agent which produces paralysis of the ciliary muscles. Mydriatic is a drug or agent that dilates the pupil. Myotic is a drug or agent that will contract the pupil.

Q. What is blepharism? Blepharospasm?

Ans. Blepharism is that condition where there is an inability on the part of the patient to refrain from blinking. Blepharospasm is a tonic or clonic spasm of the orbicularis palpebrarum superioris muscle, closing the lids firmly and due to conjunctival irritation, usually occurring where photophobia is marked.

Q. What is luxation of the lens? Miosis? Subluxation?

Ans. That condition where the crystalline lens is dislocated. Miosis is abnormal contraction of the pupil. Subluxation, when the crystalline lens is slightly displaced.

Q. What is sursumduction? Symblepharon?

Ans. The act of turning one eye upward, independent of its fellow eye. Symblepharon is an adhesion of the eyelids.

Q. What peculiarity is present when a patient has paralysis of the external rectus of the right eye?

Ans. The head will be turned to the right, and if a small object is held 16 inches in front of the patient and left of the median line the patient will have single binocular vision, but if the object is moved to the right and the patient instructed to watch it and hold the head stationary and turn the eyes, there will be diplopia when the median line is passed, and the farther to the right the object is moved the farther the two images will be separated.

Chapter X

TABLES

COMMONLY USED DISTANCES

6 meters = approximately 20 feet
5 meters = approximately 16 feet
4 meters = approximately 14 feet
3 meters = approximately 10 feet
2 meters = approximately 7 feet
1 meter = approximately 40 inches

DECENTERING EQUIVALENTS

The following is a table of decentering equivalents, showing the amount of decentration in millimeters necessary to produce various prismatic angles with lenses of different dioptric strength:

Lens	1°	2°	3°	4°	5°	6°	8°	10°
1 D.	9.4	18.8	28.3	37.7	47.2	56.5	75.8	95.2
2	4.7	9.4	14.1	18.8	23.6	28.2	37.9	47.6
3	3.1	6.3	9.4	12.6	15.7	18.8	25.4	31.7
4	2.3	4.7	7.1	9.4	11.8	14.1	18.9	23.8
5	1.9	3.8	5.7	7.5	9.4	11.3	15.2	19.0
6	1.6	3.1	4.7	6.3	7.9	9.5	12.6	15.9
7	1.3	2.7	4.0	5.4	6.7	8.1	10.8	13.5
8	1.2	2.3	3.5	4.7	5.9	7.1	9.5	11.9
9	1.0	2.1	3.1	4.2	5.2	6.3	8.4	10.5
10	.9	1.9	2.8	3.8	4.7	5.6	7.6	9.5
11	.9	1.7	2.6	3.5	4.3	5.1	6.9	8.7
12	.8	1.6	2.4	3.1	3.9	4.7	6.3	7.9
13	.7	1.4	2.2	2.9	3.6	4.3	5.8	7.3
14	.7	1.3	2.0	2.7	3.4	4.0	5.4	6.8
15	.6	1.3	1.9	2.5	3.1	3.8	5.1	6.3
16	.6	1.2	1.8	2.4	3.0	3.5	4.7	6.0
17	.6	1.1	1.7	2.2	2.8	3.4	4.5	5.6
18	.5	1.0	1.6	2.1	2.6	3.1	4.2	5.3
19	.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
20	.5	.9	1.4	1.9	2.4	2.8	3.8	4.8

Below is a similar table, but with the degrees of the prismatic effect expressed in centrads or prism-diopters:

Lens	1 Cr.	2 Cr.	3 Cr.	4 Cr.	5 Cr.	6 Cr.	8 Cr.	10 Cr.
1 D.	10.0	20.0	30.0	40.0	50.0	60.0	80.0	100.0

2	5.0	10.0	15.0	20.0	25.0	30.0	40.0	50.0
3	3.3	6.6	10.0	13.3	16.6	20.0	26.6	33.3
4	2.5	5.0	7.5	10.0	12.2	15.0	20.0	25.5
5	2.0	4.0	6.0	8.0	10.0	12.0	16.0	20.0
6	1.6	3.3	5.0	6.6	8.3	10.0	13.3	16.6
7	1.4	2.8	4.2	5.7	7.1	8.2	11.4	14.2
8	1.2	2.5	3.7	5.0	6.2	7.5	10.0	12.5
9	1.1	2.2	3.3	4.4	5.5	6.6	8.8	11.1
10	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.9
11	.9	1.9	2.8	3.7	4.6	5.5	7.3	9.0
12	.8	1.8	2.5	3.3	4.1	5.0	6.6	8.3
13	.7	1.5	2.3	3.0	3.8	4.6	6.1	7.6
14	.7	1.4	2.1	2.8	3.5	4.2	5.7	7.1
15	.6	1.3	2.0	2.6	3.3	4.0	5.3	6.6
16	.6	1.2	1.8	2.3	3.1	3.7	5.0	6.2
17	.5	1.1	1.7	2.3	2.9	3.5	4.7	5.8
18	.5	1.1	1.6	2.2	2.7	3.3	4.4	5.5
19	.5	1.0	1.5	2.1	2.6	3.1	4.2	5.2
20	.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0

DECENTERING OF READING GLASSES.

All glasses that are prescribed for reading, sewing and other forms of near work should be decentered in connection with the inclination of their planes already referred to, to the extent demanded by the inclination of the visual axes when converged for the distance worked at. This, of course, is not for the purpose of producing a prismatic effect, but to prevent it, by permitting the visual axis to pass through the optical center of the lens. Glasses for constant use should be decentered to an extent half way between the geometric center and the degree required for near work.

DISTANCE OF LENS FROM EYE

As a general proposition, the lens should be placed as near to the eye as possible without touching the eyelashes. In estimating the refraction of the eye, the convergence or divergence of the rays as they enter or emerge from the eye, are made the basis of calculation; hence the distance between the correcting lens and the surface of the eye should be as near zero as possible. In cases of presbyopia, however, and other instances where the purpose of the glasses is to adjust the accommodation for some particular working point, the patient may wear the glasses close to, or at a distance from, the eyes, according to the distance at which he is working. A convex lens gains in effect the further away it is from the eye; hence the further away the patient holds his reading or sewing or whatnot, the nearer he requires the glasses to be to his eyes, and vice versa.

FOCAL LENGTH OF LENSES.

The table below is approximately correct:

Diopters.	Inches.	Centimeters.	Millimeters.
.12	333	833	8333
.25	160	400	4000
.37	108	270	2703
.50	80	200	2000
.62	64½	161	1613
.75	53	133	1333
.87	46	115	1150
1.00	40	100	1000
1.12	36	89	893
1.25	32	80	800
1.37	29	73	730
1.50	27	67	667
1.62	25	62	617
1.75	23	57	571
1.87	21	54	535
2.00	20	50	500
2.25	18	44	444
2.50	16	40	400
2.75	15	36	364
3.00	13	33	333
3.25	12	31	308
3.50	11	29	286
3.75	10½	27	267
4.00	10	25	250
4.50	9	22	222
5.00	8	20	200
5.50	7	18	182
6.00	6½	17	167
6.50	6	15	154
7.00	5½	14	143
7.50	5¼	13	133
8.00	5	12½	125
9.00	4½	11	111
10.00	4	10	100
11.00	3½	9	91
12.00	3¼	8	83
13.00	3	7½	77
14.00	2¾	7	71
15.00	2⅔	6⅔	66⅔
16.00	2½	6¼	62½
18.00	2¼	5½	55½
20.00	2	5	50

MEASUREMENTS OF THE EYEBALL

Diameters of the adult eye:		
Antero-posterior	24.3	mm.
Transverse	23.6	mm.
Vertical	23.3	mm.
Depth of anterior chamber	11.9	mm.
Thickness of lens at rest	3.7	mm.
Thickness of lens at maximum	4.3	mm.
Radii of curvature and indices of refraction (air as base):		
Anterior surface of cornea	7.5	mm.
Substance of cornea	1.333	
Aqueous humor	1.336	
Anterior surface of lens	10.00	mm.
Substance of lens	1.43	
Posterior surface of lens	6.00	mm.
Vitreous humor	1.39	
Anterior principal focus in front of the anterior surface of the cornea	12,8326	mm.
Posterior principal focus behind the anterior surface of the cornea	22.647	mm.
The nodal point in front of the posterior surface of the crystalline lens	0.4764	mm.
The radius of this imaginary surface	5.1248	mm.
Smallest retinal image recognized	0.0044	mm.

METRIC EQUIVALENTS

1 meter = 39.37 inches
1 centimeter = .3937 inch
1 millimeter = .04 inch
10 decimeters = 1 meter
10 centimeters = 1 decimeter
10 millimeters = 1 centimeter

NEAR POINT AND AMPLITUDE OF ACCOMMODATION

Near Point in Inches.	Diopters.	Age, Years.
2⅔	14	10
3⅓	13	12
3¼	12	15
3½	11	17
4	10	20
4½	9	23
4¾	8.50	25
5	8.00	26
5¼	7.50	28
5½	7.00	30
5¾	6.75	31
6	6.50	32
6¼	6.25	33
6½	6.00	34
6¾	5.75	35
7	5.50	36
7½	5.25	37
8	5.00	38
8½	4.75	39
9	4.50	40
9½	4.25	41
10	4.00	42
10½	3.75	43
11	3.50	45
12	3.25	46
13	3.00	47
14	2.75	48
15	2.63	49
16	2.50	50
18	2.25	51
20	2.00	53
23	1.75	55
26	1.50	56
32	1.25	58
40	1.00	60
53	.75	65
160	.25	70
Infinity	.00	75

REFRACTIVE INDICES

Sea salt solution	1.375
Crown glass (varies)	1.523
Flint glass (varies)	1.623
Rock crystal	1.562
Air	1.000294
Ice	1.31
Water, distilled	1.333
White of egg	1.351
Turpentine	1.47
Alcohol	1.366
Cornea	1.333
Vitreous Humor	1.333
Aqueous Humor	1.333
Canada Balsam	1.523
after hardening	1.536
Cinnamon oil	1.60
Crystalline lens	1.43
Diamond	1.47 to 2.70
Vacuum	1.0000
Hydrogen	1.000138
Oxygen	1.000272
Ruby	1.779
Iceland spar	1.654
Pebble	1.544
Heavy Flint	1.68

Chapter XI

INDEX

LITERATURE

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